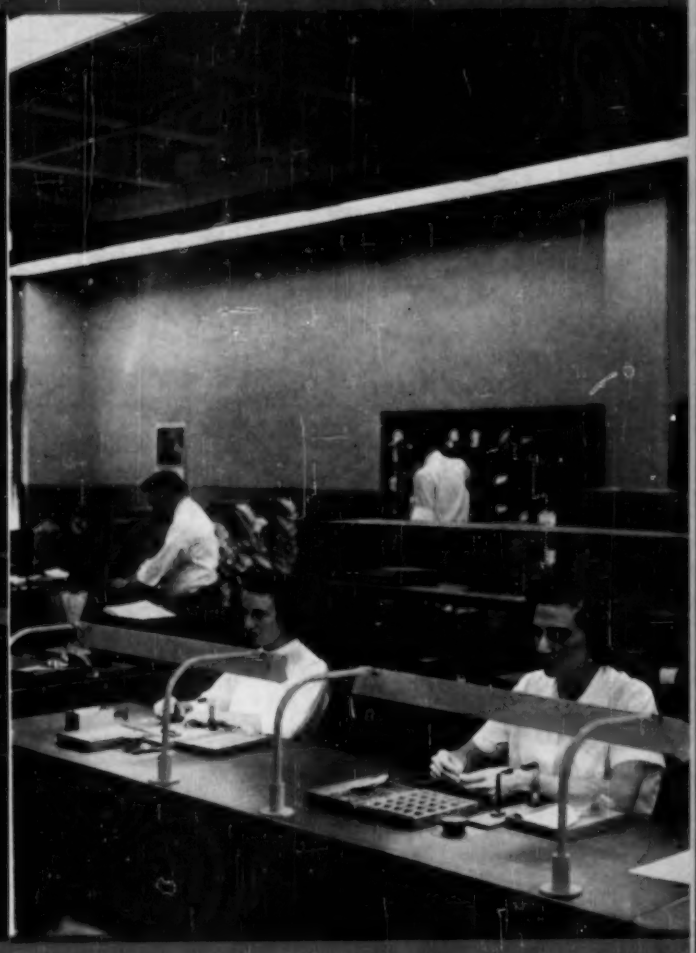
Industrial QUALITY CONTROL

SEPTEMBER, 1954 Vol. XI No. 2



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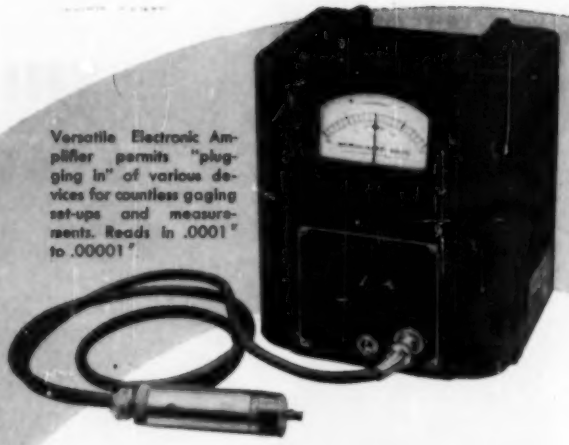

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Industrial Quality Control

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The Second Annual Awarding of the Deming Prize

The Nippon Kagaku Gijutsu Renmei (Japanese Union of Scientists and Engineers) established in 1952 the Deming Prize, which is awarded annually to the individual or company outstanding in the practice of quality control. The award was named for Dr. W. Edwards Deming, professor of statistics, New York University, in honor of his pioneering educational work in helping to establish quality control in Japanese industry. The prize consists of a cash award together with a medal bearing the likeness of Dr. Deming.

On the occasion of the second awarding of the prize in November, 1952, the presentation was made by Ichiro Ishikawa, president of the Japanese Union of Scientists and Engineers. Excerpts from his address are as follows:

Your Excellency Robert D. Murphy, the United States Ambassador to Japan, honored guests and gentlemen. You will recall, that at the time of Japan's surrender to the Allied Nations, its industrial activities had come to a virtual standstill. In manufacturing, the tools and equipment were in such a state of wear and tear that the engineers and the skilled workers were so disillusioned and bereft of hope that they tended to scatter, leaving management in a desperate and most heartrending situation. However, the combined efforts of the Allied Occupation, the Japanese Government and private enterprise succeeded gradually in restoring a semblance of order; and in 1947, by which time it was definitely recognized in every sector that production in all industrial fields would have to be revived with the greatest possible speed, the Economic and Scientific Section of the Supreme Command began to teach to key Japanese personnel in a limited number of industries the rudiments of statistical quality control. This action sparked great interest in this revolutionary method of keeping the quality of manufactured products at a desired level at little or no extra cost, and from then on the spread of this technique throughout the Japanese industry has been truly phenomenal.

In order to achieve a yet wider coverage, we invited Dr. W. Edwards Deming of New York University to lecture here in Japan, not only once but several times. His intensive 8-day courses in statistical quality control were attended in all by several thousand people.

The Union's relationship with Dr. Deming began in August, 1950, when he was in Tokyo as a consultant for the Economic and Scientific Section of the Supreme Command. He was kind enough to give a series of lectures at that time, and subsequently he was again in Japan in the summer of 1951, and early in 1952 to talk on quality control, the theory of sampling, and other statistical procedures. Dr. Deming's contribution to the advance of the practical use of statistical quality control in Japan is, consequently, immeasurable.

(Continued on page 45)

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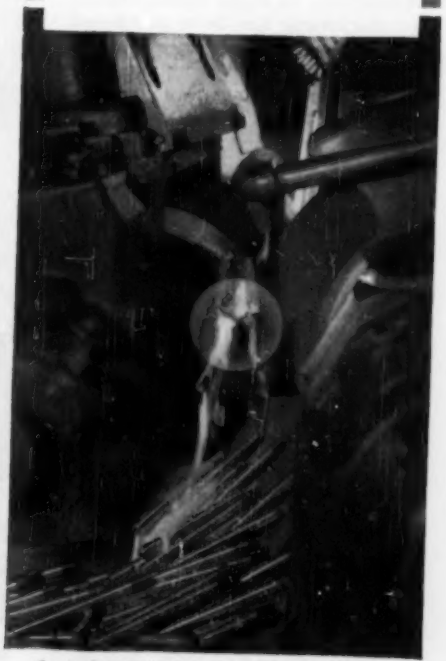

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Specialized Lighting for Inspection and Control

E. A. LINSDAY
General Electric Company

In many manufacturing processes there are tasks that present difficult seeing jobs. Examples might include the drilling of critically placed holes in metal pieces, or perhaps a machine setting which must be done with a high degree of accuracy. The inspection of leather for surface flaws, or the critical color matching of two or more materials are further illustrations. In many cases, expensive machinery has been purchased so that a job might be completed more quickly and at minimum cost. Labor also represents a goodly portion of the total costs of a product. Therefore, anything which will increase the efficiency of the worker will inevitably be reflected in increased production and lower spoilage costs. Well designed lighting will often perform this function.

The specialized forms of lighting for inspection and control are often called supplementary lighting. The name is particularly fitting since this lighting should always be designed to supplement a good general lighting system. It is poor practice to use supplementary lighting as a substitute for general illumination. A good overall system is obviously needed to supply adequate illumination for the many general seeing tasks in the factory. In addition, general lighting contributes toward providing a comfortable working environment. This is illustrated in Figs. 1 and 2 (our cover picture this month). The girls' task is the proper forming of projection lamp filaments. This operation necessitates seeing fine details on shiny wire with great accuracy. Figure 1 illustrates a makeshift supplementary lighting system, with the complete absence of general illumination. The seeing problem is complicated by direct and reflected glare from the poor supplementary lighting units, but aside from this fact, the surroundings are gloomy. Each time the girls look up from the work their eyes are forced to adjust from the high brightness of the work to the darkness of their surroundings. This adjustment occurs many times each day, and may result in visual fatigue. Compare Fig. 1 with Fig. 2 where the same task is being performed under a good system of general illumination, and with the addition of well designed supplementary lighting. Also the walls, ceiling, and other interior surfaces when finished in light colors aid greatly in making the visual environment more comfortable. The high contrast between the visual task and the surroundings has been reduced considerably.

Figure 3

Figure 4

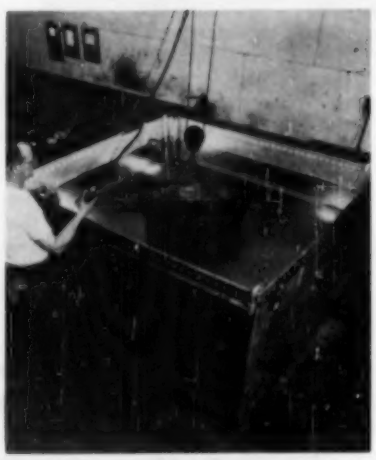

Figure 5

Supplementary lighting may be applied in four general ways. The first merely employs additional light, which should come from a well shielded source, with no special beam characteristics required. The second method involves the use of some form of directional light source. A relatively large diffuse light source, uniform in brightness, is the third type. The fourth way includes those highly specialized applications such as black light, polarized light, optical magnification, etc.

ADDITIONAL LIGHTING

Inspection techniques employing additional light are most often useful when the object or detail to be inspected is small in size or has very little contrast with its background. Figure 3 shows the use of a two-lamp, 40-watt, well-louvered fluorescent fixture to provide additional light for examining the soldered joint on a bi-metallic strip. The unit has been mounted in such a way that the increased light is achieved with comfort. This inspector has over 200 footcandles to aid her in her work.

Defects in spring steel are often hard to see because of low contrast. The problem has been solved in this plant by means of a 20-watt fluorescent lamp in a trough type reflector. (See Fig. 4.) The lamp provides adequate footcandles for the operator to inspect the steel.

Another unusual application of light for inspection is shown in Fig. 5. This tank enables the inspectors to easily and quickly determine the location of any leaks in meter assemblies. The assembly is connected to an air line at 80 pounds pressure and lowered by a hand crane until

submerged in the tank. Location of any leaks is clearly revealed by bubbles which are lighted by a 100-watt inside frosted lamp in a vapor-tight fixture. One lamp is installed in each corner of the tank, and the tank is painted white on the inside for improved light distribution.

In another plant supplementary light is used to improve the seeing of the "benching" operation shown in Fig. 6. It consists of cleaning the weld spatter from the inside of metal cylinders. A 40-watt filament lamp, mounted in a 12"x12"x8" box with an opal glass cover provides the source of light.

A lamp attached to a long handle is often used in getting needed light into normally dark areas. Figure 7 shows the use of such a device to check the interior of a bomb casing. The lamp is a standard 60-watt filament lamp in a wire guard mounted on a long piece of conduit. It is shielded in such a way that direct light from the lamp will not strike the operator in the eyes.

DIRECTIONAL LIGHTING

The second type of supplementary lighting makes use of a directional beam of light. This technique is especially useful for detecting surface flaws, irregularities, pit marks, scratches and cracks in non-specular materials. When the directional beam of light strikes the surface to be inspected at an oblique angle, the defects show up as highlights and shadows. Sometimes specular materials may be inspected in this way. The surface to be inspected will appear dark to the operator, except for the imperfections which will be bright, since they will reflect the light. Care should be taken to position the source of light in such a way that the reflected beam does not become bothersome to the operator or the other personnel.

In order to produce the desired directional beam of light for this type of supplementary lighting, narrow beam reflectors, lenses, or spot lamps are generally used.

In a paper company plant five, all-glass, sealed-beam, automobile fog lamps are used to show surface defects on coated paper sheets. (See Fig. 8.) Light is directed along the surface of the paper and the operator is not bothered by glare from the lamps as fog lamps have a very sharp cutoff.

The same technique is often used for the inspection of sheet metal.

Figure 6

Figure 7

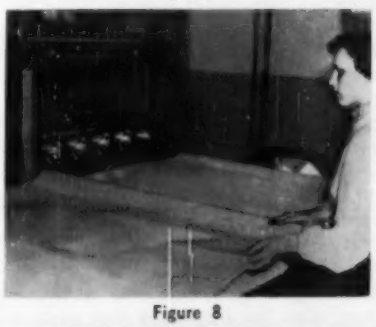

Figure 8

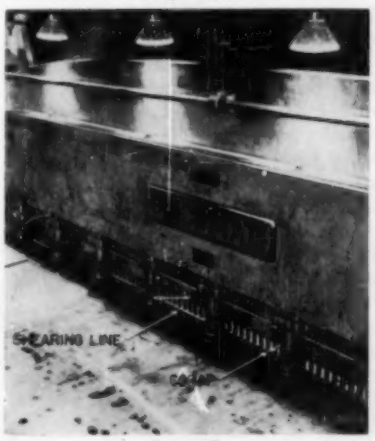

Figure 9

Eight 150-watt reflecter spot lamps on 6-inch centers can be used to light etched zinc plates for critical inspection in a lithography shop. The lamps are adjustable so that the best grazing angle can be set. Defects show up clearly and quickly.

PAR lamps inherently produce more concentrated beams than the reflector type lamps. In Fig. 9 they are used to project a shadow or guide line on material in a shearing machine. The 150-watt PAR-38 lamps are mounted in such a position that light is directed through a slot along the edge of the shear blade. A shadow is formed at the point where the blade will shear the metal. The operator can then place the material in the proper position for cutting.

Edge lighting is another good inspection technique which makes use of the directional quality of light. Figure 10 shows a sheet of plastic which is illuminated through its edge by light coming from a slot in the box below the operator. The light is provided by an 8-watt fluorescent lamp behind the slot. When viewed against a dark background such as black velvet, surface scratches as well as internal bubbles in the plastic can be easily detected. The technique is also employed with some types of glass.

DIFFUSED LIGHTING

The third technique used in supplementary lighting makes use of a diffuse light source, generally large in area and uniform in brightness for illuminating the material to be inspected. One very common use of this technique is in the photographic and printing industry. For example, negatives are transilluminated to make the details easier to see. This technique provides a good method for inspecting color-separation negatives in the printing industry.

Seams in any light fabric, such as those in a parachute, are more readily inspected when transilluminated. (See Fig. 11.) The design of the source of light consists of either filament or fluorescent lamps in a properly constructed enclosure which has been painted white on the inside and covered with translucent plastic or glass.

Many food industries use a similar method for careful inspection of their product. Here (Fig. 12) the product is checked using the transillumination technique. The luminous panel behind the bottles quickly reveals

Figure 10

Figure 11

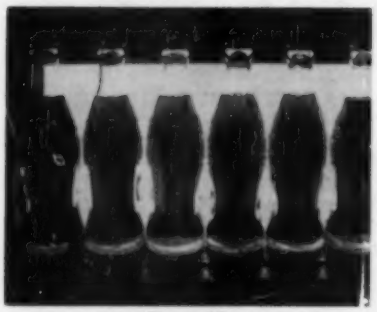

Figure 12

Figure 13

any foreign material in the bottles as well as partially filled bottles.

Controlled reflections provide us with still another inspection technique. Figure 13 shows the same type of low-brightness diffused source which we used for transillumination being put to a different use. In this case a criss-cross pattern has been painted on the translucent plastic panel. The reflections of this source from a specular material reveal the presence of dents in the material. Irregularities in the reflected lines indicate these surface defects. The material must be moved to be sure that the whole surface is covered with the pattern. This particular unit contains three 15-watt fluorescent lamps.

SPECIALIZED LIGHTING

Some types of inspection require techniques mentioned in the fourth category.

Black-light, the popular name for the near ultraviolet radiation which causes many materials to fluoresce, can be used in a variety of ways. Figure 14 shows its use in a sewing operation. The pattern is stenciled with chalk which fluoresces under black light, but which is invisible in ordinary light. A 15-watt fluorescent type black light lamp is used to provide the ultraviolet energy.

One of the chief uses of black light is in the metal industries. For the inspection of threaded shafts, they are first magnetized, then sprayed with a suspension of fluorescent ferromagnetic particles in oil, and then viewed under black light. (See Fig. 15.) Cracks cause leakage of magnetic flux, which induces a concentration of the particles at the crack. This concentration is revealed by black light. Non-magnetic materials may also be inspected for surface flaws with a slightly different technique.

Figure 16 shows the inspection of glass bulbs with polarized light. Internal strains in glass appear as streaks with color fringes. The polarizing screens in this particular instrument are located in the eye piece and directly in front of the light source—which is a filament lamp in this case. This type of inspection can also be used on radio tubes, lenses, transparent plastics, etc.

In Fig. 17 a small amount of optical magnification is provided by the inspection unit which uses a circline fluorescent lamp as its light source. Here the operator can see very fine detail.

Figure 14

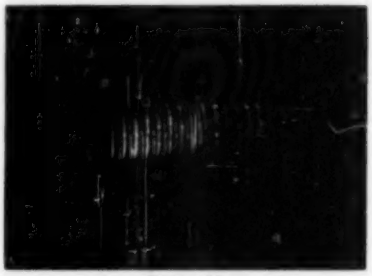

Figure 15

Figure 16

Figure 17

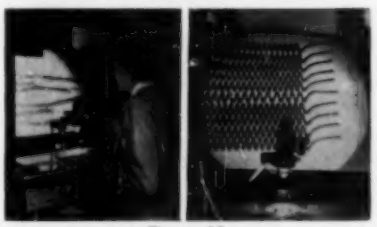

Figure 18

Figure 19

Another example of much greater optical magnification is shown in Fig. 18. Lamp filaments on the table are lighted from below and their silhouette is magnified and projected on a screen for critical inspection. Slight defects can be readily identified.

In four-color printing it is difficult to inspect the various color proofs. The yellow proof especially, has little contrast with the white background and is, therefore, very hard to see. If this proof is viewed under blue light, however, the yellow portions of the proof will absorb most of the blue light, and appear dark, while the white portions of the proof will reflect most of the blue light and will appear bright. The contrast between the proof and its background is thus increased and much greater detail can be seen. Figure 19 shows a color-proof examining booth which employs this principle. The ceiling is composed of banks of various colored fluorescent lamps. Green light is used to check the magenta (red) proofs, red light for the cyan (blue) proofs, and blue light, as mentioned, for the yellow proofs.

Critical color matching requires the use of two light sources of markedly different spectral distributions. If two paint samples, for example, will match under light from a filament lamp and also under light from a daylight fluorescent, then they will match under any light source. For critical color matching the source of light shown in Fig. 20 can be used. This source combines daylight and blue fluorescent lamps plus silvered-bowl filament lamps. By switching from the fluorescent lamps to the filament lamps satisfactory matches can be assured.

The above illustrations serve to give some idea of the many places where supplementary lighting for inspection of difficult seeing tasks help insure easy accurate seeing. In general the technique for a certain

Figure 20

job is developed after careful study of the problem. The application of fundamental principles in the control, color quality, and quantity of illumination contribute a great deal toward the elimination of the seeing "bottlenecks" which in many cases are the most troublesome features of manufacturing processes. Accurate comfortable seeing means better inspection and easier quality control. When a worker *Sees Better* he *Works Better.*

(No representation is made concerning the patent situation involving any of the above described inspection techniques, and any prospective user should make his own investigation thereof).

Air Force Surveillance Inspection and MIL-Q-5923B

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The establishment of the Department of the Air Force, in 1947, presented an ideal opportunity for re-evaluation of the entire concept of government inspection. Prior to that time the Air Corps had been a part of the Army, its procurement and inspection activities paralleling those of such technical services as the Signal Corps and the Ordnance Corps. Now, however, the infant U. S. Air Force found its procurement and inspection functions suddenly expanded — equivalent in scope to those of the Army and the Navy. Except where supply items common to all these services were involved, the Air Force was now definitely on its own.

During World War II, the Air Force had experimented with the new concept of "surveillance inspection," although at that time its principles were ill-defined and the subject of much criticism from all quarters. The reorganization of the Air Force in 1947, coming as it did within a period of relatively low procurement activity, made it possible for us to give careful consideration to every aspect of the inspection problem.

All approaches led to one inevitable conclusion: Some form of surveillance was the only means by which the Air Force could possibly meet requirements within the limitations of peacetime budgets, and at the same time provide a sound basis for emergency expansion. In other words, the big task then facing us was the need to define "surveillance" in operational terms and then to provide the organization that would be required to put such a program into effect. One of our major problems, as a matter of fact, involved the difficulty of reorienting the thinking of our own personnel.

In 1949 the Stanford Research Institute had prepared, under contract, a comprehensive review of the inspection function of the Air Force

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during World War II, and had proposed many recommendations for improvement. This review, augmenting the Air Force's own studies, helped to accelerate reorientation of the Air Force point of view.

The separation of inspection from the procurement function was one of the first important changes made, in 1947, by the establishment of the Inspection Division at headquarters, Air Materiel Command. A short time later, in view of the fact that in reality its functions transcended the field of mere inspection, the organization was redesignated as "Quality Control." The adoption of this new name did not imply that it was the intention of the Air Force to control quality, in the usual sense of the word. On the contrary, the Air Force recognized that any kind of "surveillance inspection" would be ineffective, without proper control of his own quality by the contractor.

At about the same time, realizing the need for greater utilization of statistical techniques in the field of quality control, the Air Force assigned to the new organization a statistical quality control officer. Since then, statistical quality control has become an area of ever increasing interest and activity.

During the formation period of the new AF Quality Control program, such well-known authorities as Grant, Olds, Juran, Burr, and Littauer made valuable contributions to our planning. Since the end of World War II, many readjustments have been made—in our organization, in our procedures, in our personnel policies. Through a continuing series of improvements, we now have in effect the new Specification MIL-Q-5923B.

For a better understanding of this new "Air Force Quality Assurance Program," let us first review the premises upon which it is based, and then trace some of the steps in the development of the present Air Force policy.

This policy recognizes, first of all, the unique position of the government as a consumer. This is dictated primarily by the fact that payment for the material it buys is provided by public funds. Then there is the further responsibility of the government to treat equitably all its suppliers. For each citizen has a right, in open competition, to do business with the government, with the further right to have his product impartially judged for conformance to specification requirements. Further, all citizens have the right to expect that the government will get full value for the money it spends for its material.

For various reasons, therefore, it is absolutely necessary that the government either inspect or supervise the inspection of everything it buys. These statements are not mere platitudes or arbitrary positions; they have the force of law, and are clearly spelled out in the Armed Services Procurement Regulations.

Government inspection, then, is a legal requirement. It not only protects all citizens, both as taxpayers and as competitors for government business, but it is intended also to guarantee that both in quality and in quantity, the government will get a fair return for every dollar it spends.

The present Air Force Quality Assurance Program, with its fundamental policy of "surveillance inspection," is based on the recognition that the government cannot buy the equipment it needs on any such basis as "caveat emptor." This is true for many reasons—practical, economic, and psychological.

To industry is given, in most cases, the responsibility for designing and manufacturing our equipment; so it is surely only logical that industry should also be given the responsibility for *controlling the quality* of this equipment. And instead of placing in the contractor's plant a huge force of government inspectors, it is certainly far more logical and practical to require that each contractor inspect and test his own product, and then furnish objective evidence that it meets all specified requirements. Such evidence, evaluated and verified by the government, then forms the basis of *acceptance* of the product. Surveillance inspection, as now performed by the Air Force, makes this entirely possible.

As a significant proof of this statement, it is of interest to note that 3800 Air Force inspectors, performing surveillance inspection, are today handling a greater workload than the 14,000 on our payroll at the peak of World War II—before the concept of surveillance inspection had been developed into an operational program.

The vehicle for acknowledging the contractor's responsibility for controlling the quality of his product is a standard clause, mandatory in most government supply contracts, which requires the contractor to have an inspection system acceptable to the government. In effect, then, the government buys not only the physical article, but a service—the service of a contractor's inspection to assure conformance to the article to contractual requirements.

In practice, the question of acceptability of the contractor's inspection had boiled down to the question of whether or not it suited the government inspector. Recognizing that a contract phrased in such vague terms must inevitably lead to widely divergent interpretations, the Air Force developed a specification covering the "General Requirements for a Contractor's Quality Control System." This specification is the well-known "MIL-Q-5923B."

Two key ideas are contained in the title of this specification. First, it deals with quality control, instead of the more limited field of inspection. Second, it sets forth only *general requirements*. "5923" does nothing more than to define what an acceptable quality control system is—although at the same time it does establish the minimum elements that must be present, before a quality control system can be considered acceptable. It is not intended to restrict the contractor in any way, or to tell him how to operate. It is doubtful, in fact, if there is a single, high-quality manufacturer in this country today who does not already comply in most respects with "5923"—whether or not he has ever heard of it.

For the surveillance concept to function, it is absolutely essential that the control of quality stem from the contractor and not from the government. In no other way would it be possible to assure compliance with one of our basic principles: Quality must be built into a product. "5923" simply defines and legally establishes what is required to establish an effective quality control system. At a matter of fact, the requirements of "5923" have been borrowed from the best practices of outstandingly progressive industrialists.

With further reference to the contractor's responsibility for controlling the quality of his product, it is generally agreed that regardless of the type of product manu-

factured, the quality of any product depends in the final analysis on the degree of control exercised over every step in its manufacture. Parenthetically, in speaking of "quality" in this sense, reference is made to conformance of a product to specified requirements, and not to any question of engineering sufficiency. The major factors which affect the quality of any product are:

1. The raw materials, and the various manufacturing and processing operations to which they are subjected
2. The quality of parts: components, accessories, and other subcontracted or purchased items
3. The proper handling of design changes
4. The condition and the accuracy of gages and test equipment used to determine the conformance of the product to specified requirements

It is hardly likely that there is a successful contractor in this country today, who does not spend large amounts of money and manpower on the control of these factors. This is because industry also recognizes the validity of one of our basic principles: Quality cannot be *inspected* into a product—it must be *built* in.

Essentially, then, Specification MIL-Q-5923B simply advises the contractor that the Air Force expects him to control *these factors* properly. However, it also enumerates certain things which the contractor is required to do. Incidentally, *not* having a veritable army of AF inspectors in his plant is one of the compensations a contractor receives for having an effective quality control system. "5923" also provides for him several privileges and safeguards, as well as other far-reaching benefits.

Before examining the details of "5923," it should be pointed out that there are many types of articles and procurement situations to which Specification MIL-Q-5923B does not apply. It will not normally be required in contracts, subcontracts, or purchase orders for the following:

1. Items manufactured to commercial (non-government) specifications, unless extensively modified in accordance with government specification requirements.
2. Items ordered to supplier's or vendor's catalog or part numbers, if no additional government specification requirements are applicable.
3. Government standard items (except electronic parts); such as AN standard items, JAN and MIL standard items, which are identical to either of the above; whether ordered by their commercial designation or by their government standard nomenclature.
4. General housekeeping or service items; such as office furniture and equipment, janitor equipment and small hand tools.
5. Research and development studies which do not require delivery of a physical article to the government.
6. Facilities contracts.
7. Purchase of fuels, lubricants and chemicals from refractories, manufacturers, terminals, or warehouses.
8. Procurement from foreign sources where reciprocal inspection agreements exist.
9. Purchases of raw materials, defined as materials not yet subjected to processes of manufacture into an end item.

Studying "5923B," it will be observed that it contains the *general requirements* for a quality control system that will assure that the product will meet the quality standards established by the contract. The *procedures* used to implement the requirements of the specification are to be agreed upon between the contractor and the AF inspector. In devising these procedures the contractor is given wide latitude, since the Air Force recognizes that there are many equally satisfactory ways of complying with *any* general requirement. Very likely the contractor's present procedures are essentially adequate to meet the Air Force objectives. The AF inspector is not required to go into an extensive check of the contractor's procedures, but the Air Force does require him to request correction of any procedures which do not assure adequate control of quality.

Naturally, the Air Force expects that there will be occasional disagreements as to whether or not a given procedure is adequate. In such cases, the matter should be taken up with the AF inspector's superiors in a friendly spirit of cooperation and mutual respect. We of the Air Force deplore the attitude of the few contractors who feel that since they must "live with" the AF inspector, it is best never to appeal any decision made against them.

Occasionally we hear the proposition that all implementing procedures should be agreed upon before the contract is signed and thus made contractually binding. Sober reflection should make it apparent that such a procedure would place both the contractor and the Air Force in an untenable situation. Procedures must change to keep in step with possible changes in equipment design and advances in manufacturing methods. Every dynamic manufacturing organization is constantly on the alert to improve its procedures. It is therefore obvious that all necessary procedures could not possibly be anticipated, at the time the contract is signed. Furthermore, if all procedural changes had to be covered contractually, the overall cost of procurement would be greatly increased .

Reading further in Specification MIL-Q-5923B, it will be noted that the contractor and the AF inspector are to determine which portions of the specification, if any, are to be included in subcontracts. This specification is not applicable to any subcontract that does not call for government source inspection.

Since other possible exemptions have already been given, let us now examine the "General Requirements of Specification MIL-Q-5923B."

To put these general requirements as briefly as possible, the Air Force asks that the contractor maintain an effective and economical system that will assure the adequate control of quality throughout the entire process of manufacture; that he perform sufficient inspection to assure conformance to contractual requirements; and that he make available to the AF inspector objective evidence of such inspection. It is absolutely not the intention of the Air Force to attempt dictation of the details of the contractor's system, or of the procedures which he elects to use. Specification MIL-Q-5923B

states explicitly that every quality control system is to be based on such considerations as complexity of design, interchangeability and reliability requirements, and manufacturing techniques.

In subsequent discussion of these requirements, it will be apparent that since they are so general, it would be impossible for a contractor to hand Specification "5923B" to his inspectors, expecting them to go to work directly from it. The contractor is to select or to devise procedures suitable for his own operations, as necessary to comply with the objectives of the AF requirements.

Undoubtedly, the quality control procedures in effect in most plants today would satisfy these AF objectives, even though some of these contractors may never have seen "5923B." And, to facilitate his operations, the contractor has probably given his inspectors and other personnel concerned, written descriptions of these procedures.

As a matter of fact, all the Air Force asks of a contractor operating under "5923B" is that he coordinate these procedures with the AF inspector, keep them up to date, and index them in such a way that the AF inspector can determine just how they fit into the overall system. It is not necessary that the AF inspector approve these procedures, but he is required to ask the contractor to modify those which do not furnish adequate assurance of quality.

Since the AF inspector at the contractor's plant is charged with the dual responsibility of determining that the quality control system in effect meets the general requirements of "5923B" and that the articles which he accepts for the government meet contractual requirements, the contractor should certainly recognize the necessity for the AF inspector to have a thorough understanding of his quality control procedures. In fact, as will be pointed out later, all the AF inspector's activities are geared into the contractor's quality control system.

Another requirement is that the contractor provide and maintain suitable gages and test equipment, necessary to check materials and equipment for conformance to contractual requirements. Obviously, inspection and test results are no more valid than the accuracy of the gages and test equipment used. The contractor is therefore asked to check and calibrate these devices periodically, and to maintain records or other evidence that proper control is being maintained. The frequency of such checking is left for the contractor to determine based on type, purpose, and usage of such equipment.

With respect to receiving inspection, the Air Force differentiates between subcontracted and vendor items. Subcontracted items are defined as those purchased parts, components, and assemblies over which the receiving contractor has design control. Such items should be inspected to assure conformance to the requirements of the subcontract. Vendor items, on the other hand, are those over which the prime contractor does not have design control. Vendor items should therefore be inspected and tested by the receiving contractor for conformance to whatever specifications and standards are contained in the prime contract and purchase order.

At this point, many contractors will probably be thinking, "What is new about all this? We do all these things at our own plant! So would any quality-minded manufacturer—even on his normal commercial product." That is just the way the Air Force feels about this subject. As mentioned before, we borrowed these requirements from the best industrial practice. Of course a few other requirements had to be added, to make it possible for the Air Force to perform the surveillance type of inspection.

With this digression in mind, let us go on to the subject of raw materials. In this area the Air Force has advanced far beyond the traditionally stringent government inspection requirements. Naturally, if the safety and the performance of a given article depend upon the physical and chemical properties of the raw material, it must be tested for conformance to contractually applicable specifications. So long as the test results are identifiable with the material, it is immaterial to the Air Force whether this testing is performed by the using contractor, by the supplier, or by an independent testing laboratory.

On the other hand, if the material does not affect the safety or the performance of the finished article, the only requirement is for a certificate to the effect that the material meets *applicable* specification requirements. Finally, if the physical and chemical properties of the article are of *no* importance as far as the end item is concerned, neither test reports nor certificates are necessary. (This last provision is not included in "5923B," but it is specifically covered in instructions to AF inspectors.)

The Air Force does not require any contractor to establish a statistical quality control system, although it definitely encourages the use of valid statistical techniques both for process control and for determining the acceptability of supplies. "5923B" provides that any acceptance sampling procedure, defined as anything less than 100 percent inspection, are subject to the approval of the AF inspector. This provision is intended to discourage the "hit-or-miss" methods of "spot-checking," which provide no fixed protection whatever.

Contractors who use any of the well-recognized sampling tables have absolutely no problem. For standardization purposes, the Air Force prefers the use of MIL-STD-105A. However, the AF inspector may authorize the use of other sampling plans in connection with his acceptance function.

Except in the relatively few cases where the government specification contains Classifications of Defects and AQL's, these standards are normally prepared by the contractor. With regard to process control procedures, the AF inspector may reduce final inspection requirements, if the process controls provide sufficient assurance of quality.

Another requirement that the Air Force has borrowed from modern industrial quality control practice is the use of inspection instructions. The antiquated practice of merely telling the inspector to "inspect the part to the drawing" is not looked upon with favor, unless it is clearly understood that *all* characteristics of *every* part are to be inspected. Ordinarily, this procedure does not recognize the relative importance of the various properties of the article. Unnecessary effort is therefore probably being expended on unimportant characteristics, while the really important ones are not highlighted for special attention.

Specification MIL-Q-5923B therefore requires the contractor to provide his inspectors with specific instructions as to *what* properties they

are to inspect, *how many* to inspect, and *what action* they are to take as a result of their findings. The contractor is free to use any means he prefers, in issuing these instructions, so long as they accomplish the required results. Common methods include the listing or referencing of properties on shop travelers, check lists, test procedures, and classifications of defects.

The contractor's records of inspections and tests performed, particularly if they result from adequate inspection instructions, provide much of the objective quality evidence necessary to enable the AF inspector to determine the acceptability of supplies.

Specification MIL-Q-5923B requires the contractor to maintain such records. The Air Force does not require that records be more elaborate or more detailed than necessary to provide evidence of quality. Temporary records are often entirely satisfactory, particularly in the case of preliminary or intermediate inspections of characteristics which are inspected again at a later period or are "proved out" by testing.

We of the Air Force admit that it may be argued validly that inspection records add nothing to the quality of the product. For the AF inspector, however, they are absolutely necessary: he must make his decision as to whether or not to accept the article, by an evaluation of the records and a minimum amount of product inspection for verification purposes.

Without adequate records, it would be necessary for the AF inspector to resort to a duplication of the contractor's inspection in order to assure himself that he was accepting only articles of the required quality. Obviously, such a procedure would eventually result in the assignment of many more AF inspectors to a given plant or, with the same number of AF inspectors, would certainly delay acceptance. From the contractor's point of view, analysis of his own inspection records should pay big dividends—both in determining his quality level and in correcting sources of discrepant material.

It is difficult to imagine a quality-minded manufacturer who does not perform in-process inspections. While "5923B" requires the contractor to perform those in-process inspections considered necessary to secure continued control of quality, it also permits him to use the records so as to reduce final inspection requirements.

As mentioned before, we speak of "quality" in terms of conformance of the product to specified requirements. In the new Specification MIL-Q-5923B, the contractor will find a very logical requirement for maintenance of a system to assure not only that the latest applicable drawings and other technical information are available at the time and place of inspection, but also that all obsolete information is removed. And since the AF inspector is responsible for determining that the articles he accepts are in accordance with contract requirements, it is essential that the contractor in turn assure the accomplishment of changes at the specified effective point, and also that he record such changes as accomplished.

Every Air Force contract provides that at the option of the contracting officer, material which does not conform to contract requirements may be accepted—but with a reduction in price, or under other authorized conditions. The Air Force and the Navy Bureau of Aeronautics have established a Materials Review Procedure, to permit consideration of material or equipment not in full compliance with contract requirements, because of damage or poor workmanship.

Contractors are not required to establish Materials Review Boards, *if* they elect to submit to the Air Force only material which complies fully with all requirements. However, if the contractor does wish to use the Materials Review procedure, he must follow the requirements established in "5923B."

Briefly, this specification establishes a Board, composed of the AF inspector, a contractor's inspector, and a contractor's engineer. The two contractor personnel are subject to approval by the AF inspector, who is acting for the Contracting Officer and is the man who must make the final decision as to acceptability of the material. The discrepant material may be accepted if the Board agrees unanimously that the discrepancy does not adversely affect safety, performance, or interchangeability, and if the AF inspector is satisfied that the contractor has taken adequate corrective action to prevent recurrence. We wish to emphasize that this is not by any means a "salvage" operation. It is definitely a government procedure (with contractor participation), and recurring discrepancies without corrective action are not acceptable.

Information on government source inspection is also furnished the contractor in this new specification. When conducted, government source inspection should not be misconstrued as a guarantee of final acceptance. Neither does it relieve the prime contractor of his responsibility to furnish an acceptable end article. Its primary purpose is to assist the AF inspector at the receiving contractor's plant, in determining conformance of supplies to contractual requirements. Normally, government source inspection will *not* be conducted on articles unless they affect the safety, performance, or interchangeability of the end item—or unless they cannot be satisfactorily or economically inspected upon receipt. As a rule, material which has been inspected by the government at source need not be subjected to receiving inspections which involve special equipment, excessive disassembly, or destructive testing.

The requirements just considered apply to articles which are "in production," and subject to inspection and acceptance at the contractor's plant. At the other extreme, experimental articles inspected and accepted by an ARDC Laboratory are outside the scope of "5923B." In between, however, we have articles in varying stages of development which may be subject to inspection, and often acceptance, at the contractor's plant.

To provide for all situations, Specification MIL-Q-5923B contains alternative requirements for certain elements of the contractor's quality control system. For example, there are alternative provisions which eliminate the requirements for inspection instructions, in-process inspections, and Materials Review. Considerably reduced requirements are provided for receiving inspection, inspection records, and control of engineering changes. Decision as to which requirement should be used for each of the various quality control elements is usually left to the contractor and the AF inspector. This provides the maximum in flex-

ibility, and also permits changes to be made locally, as the situation warrants.

Without discussing the detailed procedures used by the Air Force in conducting its surveillance over the contractor's quality control system, let us trace the logic behind this Air Force surveillance program:

(1) Material must conform to contract requirements.

(2) Conformance to these requirements is indicated by evidence provided by the contractor or obtained by the Air Force.

(3) The Air Force evaluates and verifies the contractor's quality evaluation data.

(4) Evidence which must be obtained by the Air Force is minimized when, through a process of verification and evaluation, the contractor's quality control system is found to be fully effective, and the quality of the contractor's product is determined to be satisfactory.

A contractor operating under Specification MIL-Q-5923B builds up in time a fund of valuable objective data concerning the quality of his product. A representative amount of this data has been verified by the Air Force. By this act of verification alone, the Air Force Quality Control organization has rendered a real and extremely valuable service to the contractor, who now has at his command independently verified information. This quality information is practically ready-made for use in controlling the quality of future production, for effecting design changes, for eliminating sources of quality deficiencies, for management evaluation of various departments, and for making quality decisions relative to the selection of subcontractors and suppliers.

Thus the coordination of the two quality control organizations — that of the contractor and that of the Air Force—will eventually result in a fund of verifiable information, independently collected, and available for the use of all echelons of factory management as well as for the Air Force.

When all these diverse factors are taken into thoughtful consideration, the new Quality Control Assurance Program will be recognized as a sound, objective approach to a problem of vital importance to our national defense. For on the *quality* of the extremely complex and costly equipment bought by our government may depend not only countless human lives, but possibly the very survival of our country.

Determining the AOQL of Single Sampling Plans

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Dodge and Romig[1] have shown how the AOQL value of a single sampling attributes plan can be derived. They also give a table, which they call Table A, that can be used to compute the AOQL value if the lot size, sample size, and acceptance number are specified; this table can also be used to compute the sample size if the lot size, the acceptance number, and the AOQL are specified. Their method, including Table A, makes use of the Poisson distribution as an approximation to the binomial distribution.

As the authors point out, this procedure is applicable under conditions where the Poisson distribution can be considered a satisfactory approximation to the binomial; usually when the fraction defective is less than or equal to 0.15. Although these conditions are usually met in practice, there are exceptions. The present paper provides an alternative development of the Dodge-Romig general formulation using the binomial distribution itself; hence, it is applicable for any fraction defective value.

The following symbols will be required:

N: the lot size

p: the incoming fraction defective value

n: the sample size

c: the acceptance number

x: the number of defectives observed in a sample of n units

AOQ: the average outgoing quality

AOQL: the average outgoing quality limit (or maximum)

p_1: the (incoming) fraction defective corresponding to the AOQL value

The Dodge and Romig formulation is based on the equation,

$$AOQ = p\left(\frac{N-n}{N}\right)\sum_{x=0}^{c}\frac{e^{-np}(np)^x}{x!}. \qquad (1)$$

Differentiating with respect to p and setting the result equal to zero ultimately gives

$$\sum_{x=0}^{c}\frac{e^{-np_1}(np_1)^x}{x!} - \frac{e^{-np_1}(np_1)^{c+1}}{c!} = 0 \qquad (2)$$

*The author wishes to acknowledge the assistance of Mr. Norman Knowlden in preparing and editing this paper.

The authors then show that

$$AOQL = y\left(\frac{1}{n} - \frac{1}{N}\right), \tag{3}$$

where

$$y = np_1 \sum_{x=0}^{c} \frac{e^{-np_1}(np_1)^x}{x!}. \tag{4}$$

With the aid of Eq. (2), y can also be defined as

$$y = \frac{e^{-np_1}(np_1)^{c+2}}{c!}. \tag{5}$$

The values of np_1 were obtained from Eq. (2) by Newton's method of approximation for c values from zero to 30 (and by the method of successive differences for c values from 31 to 40). These np_1 values were then substituted in Eqs. (4) and (5) to obtain average y values, thus providing the basic data for the authors' Table A, referred to in the opening paragraph.

Using the binomial distribution, Eq. (1) now becomes

$$AOQ = p\left(\frac{N-n}{N}\right) \sum_{x=0}^{c} C_x^n\, p^x\, (1-p)^{n-x}. \tag{6}$$

Differentiating with respect to p and setting the result equal to zero gives

$$\left(\frac{N-n}{N}\right) \sum_{x=0}^{c} C_x^n\, p^x (1-p)^{n-x}$$

$$+ p\left(\frac{N-n}{N}\right) \sum_{x=0}^{c} C_x^n\, p^{x-1}\,(x)\,(1-p)^{n-x}$$

$$- p\left(\frac{N-n}{N}\right) \sum_{x=0}^{c} C_x^n\, p^x (1-p)^{n-x-1}\,(n-x) = 0. \tag{7}$$

After cancelling the common factor and letting $y = x - 1$ in the second term, Eq. (7) reduces to

$$\sum_{x=0}^{c} C_x^n\, p^x\, (1-p)^{n-x}$$

$$+ p \sum_{y=0}^{c-1} C_y^n\, (n-y)\, p^y\, (1-p)^{n-y-1}$$

$$- p \sum_{x=0}^{c} C_x^n\, (n-x)\, p^x\, (1-p)^{n-x-1} = 0 \tag{8}$$

This, in turn, gives

$$\sum_{x=0}^{c} C_x^n\, p^x\, (1-p)^{n-x} = p(n-c)C_c^n\, p^c\, (1-p)^{n-c-1} \tag{9}$$

Using the fact that

$$(n-c)C_c^n = (c+1)C_{c+1}^n \tag{10}$$

Eq. (9) becomes

$$\sum_{x=0}^{c} C_x^n p^x (1-p)^{n-x} = (c+1)C_{c+1}^n p^{c+1}(1-p)^{n-c-1} \tag{11}$$

the binominal analogue of Eq. (2). This can be rewritten as

$$\sum_{x=0}^{c+1} C_x^n\, p^x\, (1-p)^{n-x} = [(c+1)+1]\, C_{c+1}^n\, p^{c+1}\, (1-p)^{n-c-1} \tag{12}$$

Equation (12) can finally be reduced to the extremely simple form,

$$\frac{c+1}{c+2} = \frac{\sum_{x=0}^{c} C_x^n\, p_1^x\, (1-p_1)^{n-x}}{\sum_{x=0}^{c+1} C_x^n\, p_1^x\, (1-p_1)^{n-x}} \tag{13}$$

The left-hand side of the equation is known immediately from the acceptance number considered. The right-hand side represents the ratio of the probability of acceptance (of quality p_1) with the acceptance number, c, to the probability of acceptance with the acceptance number, c + 1.

Equation (13) may be evaluated directly with the aid, say, of the binomial tables of the National Bureau of Standards.[2] (In using these tables, it will usually be necessary to use interpolation procedures like those illustrated below.) The p_1 value obtained can then be used to compute y in, say, the binomial analogue to Eq. (4) and then the AOQL in Eq. (3). It should be repeated that this procedure is applicable for any value of p_1 since it is based directly on the binomial distribution.

It is instructive to apply the procedure to a sampling plan taken from MIL-STD 105-A Sampling Tables.[3] This is a particularly appropriate choice since these tables do not provide AOQL values. The plan selected has an n value of 10 and a c value of 1 (and is intended for sample-size code letter E and an AQL of 6.5 percent).

In applying the National Bureau of Standard's binomial tables, Eq. (13) can be written in revised form as

$$\frac{c+1}{c+2} = \frac{1 - \sum_{x=c+1}^{n} C_x^n\, p_1^x\, (1-p_1)^{n-x}}{1 - \sum_{x=c+2}^{n} C_x^n\, p_1^x\, (1-p_1)^{n-x}} \tag{14}$$

In the present case, the value of the left-hand side of (14) is 0.666667. The tables show that for a p of 0.14 and an n of 10, the right-hand ratio is 0.581560/0.845470 which reduces to 0.687584. For a p of 0.15 and an n of 10, the ratio is 0.544300/0.820196 which reduces to 0.663622. Linear interpolation between these values gives a p_1 value of 14.87 percent.

It is now necessary to find

$$y = np_1\left(\sum_{x=0}^{c} C_x^n\, p_1^x\, (1-p_1)^{n-x}\right) \tag{15}$$

for a p_1 value of 14.87 percent. Linear interpolation on the numerators of the ratios obtained for a p of 0.14 and a p of 0.15 gives 0.5491 for the second factor; substitution then gives

$$y = 10\ (.1487)\,(.5491), \tag{16}$$

which reduces to 0.8165. Finally,

$$\text{AOQL} = 0.8165\left(\frac{1}{10} - \frac{1}{50}\right), \tag{17}$$

where N, the lot size, has been taken to be 50. The AOQL is thus computed to be 6.53 percent. (The Table A value in this case gives an AOQL of 6.73 percent).

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Short Runs

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INTRODUCTION

Why is it thought by many that statistical methods are not particularly applicable to short runs? One of the reasons would seem to be that statistics used to be largely concerned with "masses of data." With the development of the theory of small samples (including, for example, that of ranges) during the 1920's, we no longer need be concerned with masses of data. Such theory enables us to compare one sample of two measurements with another similar sized sample, or even two measurements with one! If we define statistics as the science of dealing with data markedly affected by chance causes, then the application to short runs becomes more reasonable. We do not need mass production, all we need is some degree of repetitive production.

A second reason, related to the first is that in a short run, which may be "short" either in number of pieces or in the time it takes to get finished, we cannot collect enough data to complete our preliminary run of, perhaps, 25 samples of four measurements each. The run is gone and all pieces produced before we can even collect our 100 measurements, let alone analyze them. How then can statistical quality control possibly help us? Believe it or not, the methods can be of vital help to us.

We shall make five general suggestions, which should help in applying statistical quality control to short runs.

FIRST SUGGESTION—FRACTION DEFECTIVE CHARTS

A method used effectively, for example, by Carl Schmidt[1] on short runs in the production of the Norden bomb sight is the following: the plan is to use fraction defective charts widely on the various machines. On each machine there is a p or np chart. The sample size may be a typical-sized whole run, perhaps 100 pieces, or if some runs are of only 50 pieces, then the sample size can be 50, and two such samples can be plotted when we have a run of 100.

Now the important point is that on any one machine the part number may well vary from one sample to the next. But it is not necessary that we start a new chart for each different part number. In general the different jobs given to one particular machine will be quite similar. For each sample and point, we should have a record of the part number, time, operator, inspector, gage number, etc.

Now what do we get from such charts? A point out of control on the high side can of course sometimes be explained by the fact that that point was for an unusually difficult part number. If this is *truly* the case then no action is indicated, but if a point is out for a part which is not exceptionally difficult, the reason should be sought. We look for two things: (1) poor level of $\bar{p}$ for a particular machine, whether in control or not, and (2) erratic performance shown by lack of control on the p chart even if $\bar{p}$ is good. In either case, we can then move in on that machine with the more powerful $\bar{X}$ and R charts for a more thorough study of why that machine, or the persons operating it, are running into trouble.

The plan then is to use the relatively economical fraction defective chart as a "watchdog" to tell where to place the more powerful $\bar{X}$ and R charts for "trouble shooting."

This plan works especially well where there is 100 percent inspection of the product, which is often the case with short runs. It can, however, also be used when we do not inspect everything 100 percent, by taking at random a fixed sample size from each run, say, 25 pieces. This then gives a sampling indication of the quality for each run.

Such records as we have here described can also be used to make studies and charts for sub-departments and departments for executive control. Moreover the psychological effect of such charts plotted at the machines and in offices can be a powerful incentive toward improvement.

Another possibility in the use of np charts in short runs is to use an artificial definition of a "defective," that is, by narrowing down the "specification" band so as to give, perhaps, 30 percent of the pieces outside, even when the process is meeting blue-print specifications adequately.[2, 3]

SECOND SUGGESTION—COMPLETE STUDIES

It is often worthwhile to make a "100 percent study" of a product or process. Each piece is measured in the order produced, even though this results in far more measurements than are ever likely to be taken in normal control of the process. We are here thinking particularly of the high-speed operations with large output per minute or even per second. The production is likely to be far too rapid to be kept up with by an inspector or even several of them. But if the material can be kept in the order of production and then measured at whatever pace is possible, the results, in order of production, become available.

Now what good can this do us, except to sort the good from the defective? We cannot take action on the process to make it do better on the material which it has already produced. But we can learn much for future runs! Let us see. At Perfect Circle Corporation, makers of piston rings, such a study was made. The dimension in question was the edge width or thickness of the ring castings, after the first rough grinding operation. Although several per second are ground between disc grinders, a run of 6000 was made, with only one resetting, and the order in which they were ground was carefully preserved. The edge width of each was measured and the 6000 consecutive individual measurements, X, were plotted.

The resulting picture gave them an entirely new viewpoint on their process. Previously they had thought that the obtained dimensions fairly well filled up the specification band. But the graph clearly showed that most of the time the natural fluctuations of the process during any short period of time gave a band hardly a third as wide as the specification band. There were some assignable causes present, obvious without the use of any control limits. Some of the corresponding castings were out of the specifications. One unusual assignable cause which was unexplained gave a sudden short run of very high edge widths. There was also a long gradual increase in edge width as the grinders wore. It was obvious too, how the resulting product could seem largely to fill the specification band, when all the material produced was considered together, including the assignable causes, the grinder wear, and the perhaps too frequent resettings of the grinder.

This study opened up a whole new viewpoint in improving the grinding processes, and the results hit "pay dirt."

Such data as just discussed can be analyzed as an X chart, or by $\overline{X}$, R charts, although some things may stand out like "sore thumbs". In any case one should determine from such a study the inherent process capability, σ_x' from R/d_2.

By such studies of far more complete data than we ever intend to collect regularly, we can learn much to help us better control future runs, even though we can do nothing about the present run. Careful analysis of the past can help us control the future.

THIRD SUGGESTION—MEASUREMENT CHARTS

Probably the most important suggestion we can make is to work toward getting control charts set up at once on each short run. Then the very first 3, 4 or 5 pieces of the run can form the first sample, from which X and R points are plotted. If either point is out of its control band, then action is immediately indicated without waiting for 20 samples. Everyone will admit that this approach is desirable, but how is it possible? Let us see.

Consider a lathe which is often used on work requiring specifications of ± .0010 in., or ± 10 ten-thousandths of an inch, in coded units. It does not in general matter whether we have ever run the particular desired nominal diameter before, as long as it is within the normal capacity of the machine. Let us say that in the past we have found the lathe to run in control on the R chart, even though some drifting of level on the $\overline{X}$ chart has been observed at times. The last previous run of data appears in Fig. 1A. There it will be seen that there is perfect control, with $\overline{R} = 7.88$ (in .0001"). From this we estimate

$$\sigma_x' = \frac{\overline{R}}{d_2} = \frac{7.88}{2.326} = 3.39.$$

The "natural spread" of the process is thus $\pm 3\sigma_x' = \pm 3\ (3.39) = \pm 10.17$, which will include about 99.5 percent or so of the pieces. But to be sure of adequately meeting specifications of ±10 we must be sure to set the process at just about the nominal dimension. For example, if we are off as much as 0.0003 in. we will have about two percent of the pieces out, etc.

Now although the data in Fig. 1A, were for an outside diameter of 3.6200 ±.0010 in., we can immediately set up on a new job having specifications of, say 3.8750 ±.0010 in. We simply set the gage to read 0 at 3.8750 in. and record in ten-thousandths from this. The control limits (for n = 5) are set, using either:

$$\overline{X}\text{: } 0 \pm A\sigma' = 0 \pm 1.342\ (3.39) = \pm 4.55$$

$$\text{R: } D_1\,\sigma' = 0\ (3.39) = 0$$

$$D_2\,\sigma' = 4.918\ (3.39) = 16.7$$

or

$$\overline{X}\text{: } 0 \pm A_2\overline{R} = 0 \pm .577\ (7.88) = \pm 4.55$$

$$\text{R: } D_3\overline{R} = 0\ (7.88) = 0$$

$$D_4\overline{R} = 2.115\ (7.88) = 16.7$$

It should be noted that the two statistical values used are a mixture, since one is from the blue-print, i.e. the 0 for $\overline{X}'$, and the other from past data, i.e. σ' or $\overline{R}$.

These control limits are now drawn on the chart before a single piece is run. After the first five are made and measured the first pair of points is plotted. If the $\overline{X}$ point is outside of the control band it is an indication that the setting is wrong.* On the other hand if a point is above the upper control limit for ranges, then this is an indication of excessive process variability. Such a situation is very dangerous to meeting specifications, since for this lathe, $\pm 3\sigma_x' = \pm 3(3.39) = \pm 10.17$, and hence any increase in σ_x' is going to give us pieces out of specification, even if the process level is right on the nominal. However, in practice an initial R point above the upper control limit may well be due to set-up pieces getting into the original sample. To avoid this

*Such a point can of course occasionally be the result of excess process variability, even though the process is set perfectly on the nominal, and even with the corresponding range point below the upper control limit for ranges. However, since the R chart has been in control, such a situation is quite unlikely.

trouble we must be careful to take for the sample only those after the set-up man is ready for the run to begin.

Thus we are now ready for the control chart record to help us follow the run as it proceeds. We may use all pieces produced or a sample from time to time as desired.

Now the foregoing illustrated the case in which we have a process just about capable of meeting the specifications set. What can we do in case the process variability is considerably greater or less than this? Let us consider Fig. 1B. This figure shows 25 samples from a process not adequately meeting specifications, even though it is perfectly centered on zero. For it ($n = 5$):

$$\overline{\overline{X}} = -.12$$

$$\overline{R} = 12.76$$

$$\sigma' = \frac{12.76}{2.326} = 5.49.$$

Thus there will be about seven percent outside of specifications, as can be found from a normal curve table. Hence this process is not capable of fully meeting specifications of ± 10, since it is in control with respect to its limits:

$$\overline{X}: \quad -.12 \pm .577\ (12.76) = -7.48, +7.24$$

$$R: \quad 0 \text{ and } 2.115\ (12.76) = 27.0.$$

In such a situation there are only three things to do: make a radical change in the process, loosen the specifications, or sort 100 percent. If the first two are not possible then we must aim at minimizing the percentage of pieces outside the specifications, through maintaining $\overline{X}'$ close to the nominal. Or else one can seek a minimum cost balance between scrap and rework as described by Springer.[4] In either case it is well to maintain a control chart, determined from the actual process average range, $\overline{R}$, and the desired mean dimension. Using such a chart will help avoid unnecessary resetting, which can only serve to give further variability to a process already too variable.

Now let us consider the opposite situation where the process variability is well below what would be required to just meet the specifications. Consider now Fig. 1C. Looking at the $\overline{X}$ chart, one would judge that the process was not meeting specification from being set too high. But such is definitely not the case, since we have good control and

$$\overline{\overline{X}} = 5.21$$

$$\overline{R} = 3.76$$

$$\sigma' = 1.62$$

$$\overline{\overline{X}} \pm 3\sigma' = 0.35, 10.07$$

Hence only about one in 1000 will be out of specifications.

In a case with such low variability as this one, it is not reasonable to require that the process meet ordinary control limits for $\overline{X}$,* namely

*Unless we wish to seek out assignable causes in the way it behaves. If we wish to do this we should use ordinary limits.

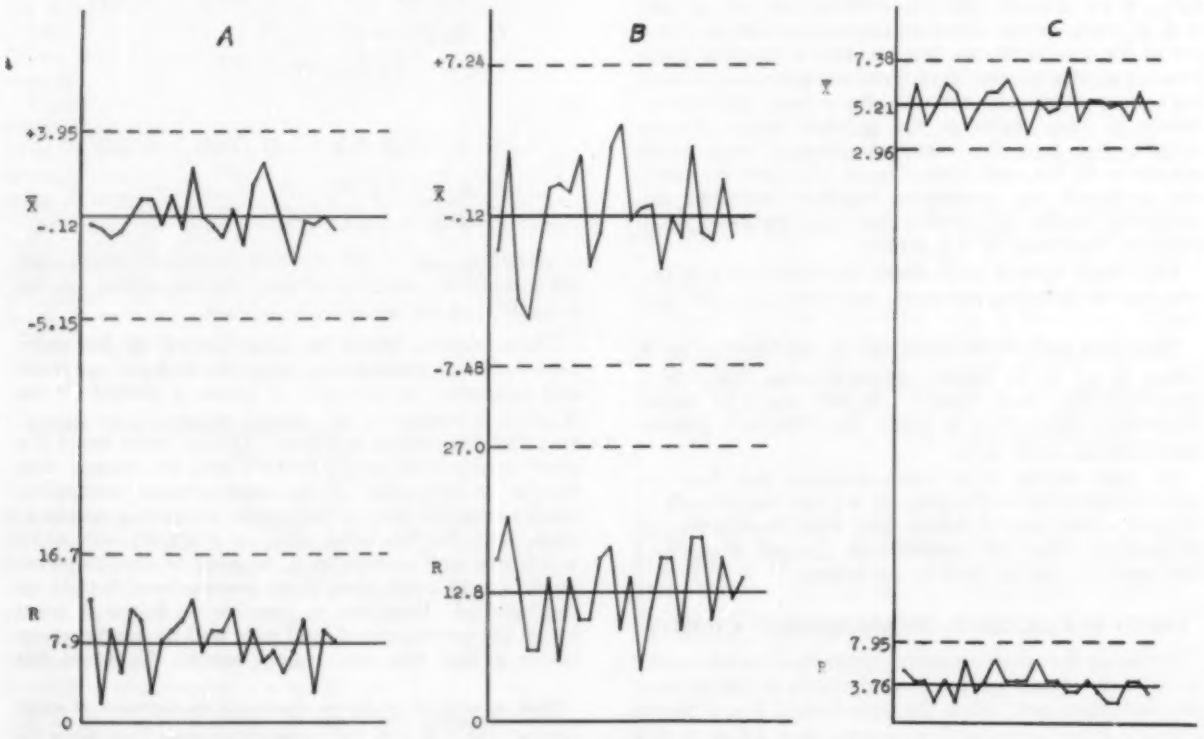

Figure 1

$$0 \pm A_2\bar{R} = 0 \pm .577(3.76) = \pm 2.17,$$

because, with such small process variability, it simply is not necessary to have the process mean close to the nominal, i.e., 0. In fact we can afford to let the process mean reach a point within $3\sigma'$ of the specifications. Thus, as long as the process mean is not above

$$10 - 3\sigma' = 10 - 3(1.62) = +5.14$$

nor below −5.14, the process will meet specifications. Hence one may well use modified limits for $\bar{X}$. Figure 2 shows the situation. When $\bar{X}'$ is at either +5.14 or −5.14, the distribution of individuals, X, is still at a safe distance from the specifications, and hence these are called respectively "maximum" and "minimum safe process averages." Now if $\bar{X}'$ is at either of these levels, where will the $\bar{X}$'s be? They will of course lie within $\pm A_2\bar{R} = \pm 2.17$ of these levels. (See Fig. 2) Now if an $\bar{X}$ point lies above, say, (5.14 + 2.17), or +7.31, then surely $\bar{X}'$ is above the maximum safe level of 5.14, hence we should adjust the process. On the other hand, if we get an $\bar{X}$ point below (5.14 + 2.17) then are we safe? The answer is "not necessarily." The reason is that the true process average could well be considerably above the maximum safe process average, 5.14, and still yield $\bar{X}$ points below 7.31. In fact $\bar{X}'$ could be at 7.31, (thus giving about eight percent of the pieces defective), and half the $\bar{X}$ points would lie below 7.31. The first two or three $\bar{X}$ points could readily all lie below 7.31, and thus leave us content, even though eight percent of the pieces are too high.

The reason for this rather lengthy discussion is that such limits are often used as "modified limits." The present author suggests that instead of going back up from the maximum safe process average an amount equal to $A_2\bar{R} = 3\sigma_{\bar{X}}$, we instead go back up only $\frac{2}{3}A_2\bar{R} = 2\sigma_{\bar{X}}$. Such a modified limit gives a much better chance to reject a setting which is too high, while not unduly increasing the chance of calling for a resetting when such is not necessary. Because of the better balance between the risks on these two errors we recommend:

$$\text{Upper modified limit} = \text{Upper spec.} - 3\sigma_x' + 2\sigma_{\bar{X}}'$$
$$= \text{Upper spec.} - 3\bar{R}/d_2 + 2A_2\bar{R}/3$$
$$= \text{Upper spec.} - W\bar{R},$$
$$\text{Lower modified limit} = \text{Lower spec.} + W\bar{R}$$

where

$$W = (3/d_2 - 2A_2/3),$$

See Table I for values of W, and for a more complete discussion of the subject of modified limits, see a book by the author.[5]

TABLE 1—Multipliers for $\bar{R}$ for Finding $2\sigma_{\bar{X}}$ Modified Limits.
$W = 3/d_2 - 2A_2/3$

n	2	3	4	5	6
W	1.41	1.09	.97	.91	.86

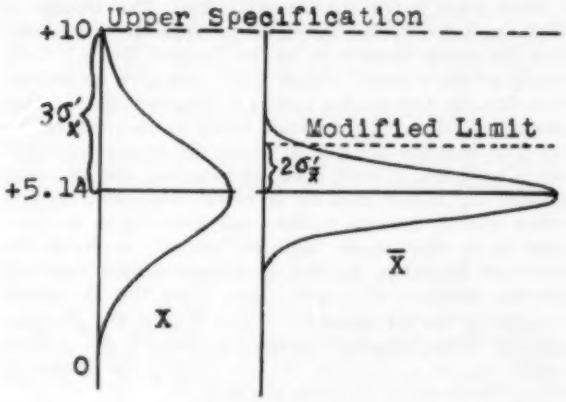

Figure 2

To summarize this suggestion we have the following:

I. We must have a good estimate of process variability on ordinary jobs, through having a range chart in control on previous operations and using $\sigma_x' = \bar{R}/d_2$

II. Cases

A. Specified tolerance less than $8\sigma_x'$

1. Using ordinary control limits, set with mean at nominal and using the known $\bar{R}$.
2. If tolerance is smaller than $6\sigma_x'$, should try to get a better operation or relax specs. to avoid necessity for 100 percent inspection and scrap loss.
3. If tolerance is between $6\sigma_x'$ and $8\sigma_x'$, use limits as in 1, set up at beginning of each run.

B. Specified tolerance over $8\sigma_x'$

1. Can let $\bar{X}'$ vary considerably.
2. If we want to seek assignable causes, use ordinary control limits as in A1.
3. If, as is the usual case with such generous specifications, we no longer seek assignable causes, use modified limits:

U.Spec. $- W\bar{R}$

L.Spec. $+ W\bar{R}$

III. Always maintain an R chart.

WHAT NOT TO DO

There has been some slight tendency and much natural wish to set initial "control limits" directly from the specifications at hand. This is distinctly undesirable. The reason is perhaps best indicated by the statement, "Machines don't read blueprints." According to this approach, one would take the specified tolerance as though it were $6\sigma_x'$, and divide by six to get the required σ_x'. Then this and the nominal mean dimension would be used to set the "control limits."

Now what is the trouble with this? The trouble is that one loses almost all of the probability interpretation for points in relation to the "control limits." Certainly points outside of such limits can give no indication that the process has suddenly changed, that is, that there has arisen an assignable cause in the process. To see this, consider the case in which the process variability is too great to meet specifications, say, the tolerance is only $4\sigma_x'$ rather than six or more. Suppose then that when such is the case without our knowing it, we proceed to do what seems "natural," namely, to divide the specified tolerance by six, to determine the required process standard deviation. Then using this as though it were σ_x' we set limits for $\bar{X}$ and R as in the previous section. What happens? Nothing happens, if our process really has its σ_x' equal to about a sixth of the tolerance. Such, however, is not often the case.

Now look at Fig. 3, wherein "limits" for both $\bar{X}$ and R have been thus set from the ± 10 specifications. These are the same points as in Fig. 1B and 1C. Consider the first half of the charts. As is seen, four points lie above the upper "control limit" for R's, even though this process was actually in control with respect to itself, as seen in Fig. 1B. Also a point outside of the "control limits" for averages $\bar{X}$, such as sample number 4, does not indicate an assignable cause, nor that the process is out of control. (Again see Fig. 1B.)

Secondly, look at the second part of Fig. 3. Most of the $\bar{X}$ points lie above the upper "control limit." Does this mean lack of control? Certainly not, since the process is in control. It merely means that the level is away from the nominal. Look also at the accompanying range chart. All points are below the "center line." Hence one would judge that there was an assignable cause. But such is not the case. The process is in control with respect to itself, and the variability is considerably less than that which is just capable of meeting specifications. The latter is the only valid interpretation one should get from the R chart.

If such "control limits" do not tell about assignable causes, do they tell us when we are meeting specifications? Not very well. In the first place all but one of the $\bar{X}$ points is inside the "control limits" in the left part of Fig. 3, and yet seven percent of the pieces were running outside. The range chart here is very helpful and important, however. It does tell us, by four points out and other high ones, that the process variability is not small enough to meet specifications. But it fails to tell us whether or not the variability is in control with respect to itself.

Next look at the R chart in the second part of Fig. 3. It tells us that the process variability is considerably better than that required for meeting specifications. But, how much better is it? The $\bar{X}$ chart on the other hand seems to shriek for help because so many points are above the upper "control limit." Most persons seeing the chart with such "limits" would think that many pieces are out of specifications, but as we have seen, almost none are (none in 125).

Thus use of "limits" set from the specifications rather than the process can easily cause personnel to lose confidence in, not only such charts, but also conventional control charts as well.

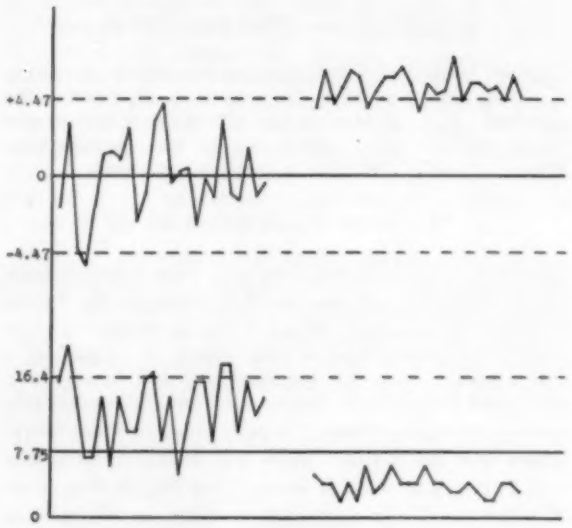

Figure 3

Accordingly it seems best to avoid all use of such preset "limits." It is better to wait until some evidence on σ_x' has accumulated. To gain such information rapidly one may use our second suggestion.

FOURTH SUGGESTION—CHECK OF SETTING

A helpful possibility in short runs is a statistical check of the process average. It is certainly important in short runs that the process level be set correctly initially, and that it be maintained at a safe position. Statistical checks of setting are suggested only if we are not interested in finding assignable causes, since if we are seeking them we should use ordinary control charts as discussed in the third suggestion.

There are two main cases: process standard deviation σ' known and σ' unknown. Since the former case is so much more efficient and simple, we should always work toward it. In fact if we do not know enough about our process to give at least a good estimate of σ', it is somewhat doubtful whether we should use statistical checks of the setting.

Let us then assume that σ' is known. There are then two cases to consider: (1) a one-way check, in which there is only one specification or in which there are two specifications which are, say, $8\sigma'$ or more apart, and (2) a two-way check when there are two specifications rather uncomfortably close together, perhaps 5, 6 or $7\sigma'$ apart. Also one may use single, double or sequential sampling.

Simple single-sampling plans are given in reference 5. They are as follows:

1. One way check. Select a "safe" process average at about 3 or $3.5\sigma'$ away from the specification, and an "unsafe" process average exactly $1\sigma'$ closer to the specification than the safe average. Take as K, a point half way between these two process averages. It will be about 2.5 or $3\sigma'$ from the specification. The sampling plan then is as follows: Take seven measurements and find $\bar{X}$. If

$\bar{X}$ is closer to the specification than K is, reject the setting; otherwise accept.

This sampling plan has risks (or probabilities) equal to 0.093, of wrong decisions: (a) acceptance if $\bar{X}'$ is at the "unsafe" process average and (b) rejection if $\bar{X}'$ is at the "safe" process average. The farther K is from the specification the more conservative we are being. The operating characteristic curve can be drawn for any given choice of K, in terms of the percentage of pieces outside of specifications.[5]

2. Two way check. Let $\bar{X}_0'$ be the nominal measurement at the middle of the specification band. Then the sampling plan is: Take nine measurements. If $\bar{X}$ lies within $\bar{X}_0' \pm .573\sigma'$, approve the setting; otherwise reject it.

   This sampling plan has a risk of 0.10 of erroneously approving a process setting which is off by $1\sigma'$, and a risk of 0.086 of erroneously rejecting a setting which is right at $\bar{X}_0'$. Again an operating characteristic curve can well be drawn.

Sequential plans which require no additional calculation, and which provide similar protection to the plans just discussed are given in reference 6. They have the advantage of giving a decision on considerably less average sample sizes than single plans, especially if the process level is very good or bad. Double-sampling plans are given in Bowker and Goode.[7] In fact this book is excellent for single-sampling checks as well.

In using any of these known-σ' plans it is well to err on the side of estimating σ' too large rather than too small, to be conservative.

If σ' is unknown then it is possible to use single sampling[5,7] or sequential sampling.[8] The latter in particular is difficult to use for such applications as are under discussion here. A modification of the plans in Bowker and Goode, using ranges seems quite feasible, but requires samples of 20 to gain the same discriminating power as for 15, using the sample standard deviation.[9,10] Such sample sizes are needed to give approximately the same discriminating power as the above known-standard-deviation plans have. These plans would call for acceptance relative to, say, an upper specification if

$$\bar{X} \leq \text{U.Spec.} - ks,$$

or if

$$\bar{X} \leq \text{U.Spec.} - k\bar{R}/d_2,$$

where

$$s = \sqrt{\frac{\Sigma(X - \bar{X})^2}{n - 1}} \qquad (n = 15)$$

$\bar{R}$ is the average range for the 20 measurements, broken into four samples of five each, and $d_2 = 2.326$ (for $n = 5$). Using $k = 2.0$ gives the following relative to the specification:

$P_a = 0.90$ for fraction defective $= 0.0050$

$P_a = 0.10$ for fraction defective $= 0.0825$

for the plan using s, while for that using $\bar{R}$ we have

$P_a = 0.90$ for fraction defective $= 0.0050$

$P_a = 0.10$ for fraction defective $= 0.0725$.

As mentioned before it would seem desirable always to work toward the use of known-standard-deviation plans.

FIFTH SUGGESTION—X CHARTS

Control charts for individuals, X, can be useful in short runs, especially where pieces are produced, or measurements are taken, at considerable time intervals. On the basis of previous data, preferably, or from the present data, center line and control limits can be drawn, and each measurement immediately plotted as soon as it is taken. As in the Third Suggestion, if we have a good estimate of σ' from other runs of similar jobs, we can use this, together with the nominal measurement as $\bar{X}'$, to set limits for immediate use on the very first measurement.

Excellent examples of the X chart are given in the ASTM Manual.[11] Four examples are given there to illustrate the four cases of standard given or analysis of past data, with rational sub-groups or using the moving range. If one has plenty of data, use of samples of four or five measurements from which ranges are obtained is probably best. But if data are meagre one can well use the moving range, that is, the range between the first two X's, then that between the second and third, etc. In either case we divide $\bar{R}$ by d_2 for the sample size used. This gives us an estimate of σ', the standard deviation for individuals.

The author is inclined to suggest the use of $2\sigma'$ limits rather than $3\sigma'$ limits. The reason is that control charts X are not as efficient as $\bar{X}$ charts at catching a process shift, that is, it takes longer on the average, in point of the number of X's, to get a point out on the X chart than on the $\bar{X}$ chart. To compensate somewhat for this we can use $2\sigma'$ limits instead. This will increase the chart's efficiency at catching a shift, but this will of course increase the risk of finding a point out when there is no process change at all. Nevertheless $2\sigma'$ limits would seem to the author to give a better balance between the two risks. Thus we can use

$$\bar{X}' \pm 2\bar{R}/d_2 \quad \text{or}$$

$$\bar{\bar{X}} \pm 2\bar{R}/d_2 \ .$$

If much importance is attached to each measurement and the measurements are rather far apart in point of time, it may even be desirable to use four charts, an X chart for the last measurement, an $\bar{X}$ chart for the average of the last two, an $\bar{X}$ chart for the last four, and a range chart for the range of the last two. Note that these points should not all be plotted at the same vertical point in the time scale. The moving range and the $\bar{X}$ for two should be plotted half a time unit back from the last X, and the $\bar{X}$ for four should be plotted one and a half units back.

POTENTIAL APPLICATIONS

The foregoing methods would seem to be applicable not only to metal working industry, but to most others including metallurgical, chemical, foods, fabricating and textiles, wherever measurements are taken. The methods may not always pay their way, but will do so in economically important spots.

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Designing Experiments to Isolate Sources of Variation*

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AN experimenter, immersed in the detail of carrying through his experimental procedures, may easily forget that the interpretation of his results will depend on an abstract pattern or model. Usually the model contains assumptions which cannot safely be accepted without evidence, yet conclusions cannot be drawn from the experimental results without assurance that the assumptions are valid.

The theory of experimental design deals with questions such as these, with models which can serve as patterns on which experiments and their interpretation can be based and with the planning of experiments which will conform to these models or, at least, will test their validity.

It is proposed here to discuss these ideas, through the manner in which they bear on an illustrative experimental situation.

Let us suppose that we wish to compare the wearing qualities of two types of automobile tire (assuming that we have a means of measuring wear) by running them on the same car at the same time. If we have two tires of one type (A) and two of the other (B), it may be possible to mount these four tires on a car and, by making wear measurements, to obtain a legitimate comparison between tires A and B. What factors must be taken into account and what conditions must be fulfilled in order that the comparison be, in fact, legitimate and how must the test be conducted so that we may be sure that these conditions really are satisfied?

Some of the factors are surely well known. We know, for example, that tires on the front wheels of a car are likely to wear at a different rate from those on the back wheels. It seems likely, also, that the rates of wear are different on the two sides of the car. Beyond these facts or guesses, our experience does not carry us.

Now, among the four wheels of a car there are three independent comparisons, that is, three degrees of freedom. In the light of what has been said, we would choose to think of them in the following terms.

(α) Front vs. rear; in symbols, we might represent this by

$$LF + RF - LR - RR.$$

(β) Left side vs. right side;

$$LF - RF + LR - RR.$$

*Paper presented on the program of the Sixth Annual Convention, ASQC, Syracuse, N.Y., May 1952.

(γ) The interaction of α and β; LF − RF − LR + RR.

If, for example, the two A tires were mounted on the front and the B tires on the rear, the difference between the two types of tire would be identified with α and could not be distinguished from a difference between front and rear. This would be an intolerable experimental plan, of course. The same sort of reasoning would prevent us from putting both A's on one side of the car and both B's on the other, which would identify the difference between tires with β. The only remaining possibility is to identify the difference between tires with γ, which puts one A and one B on each end and one A and one B on each side. It must be granted, though, that we have no real assurance that γ does not receive important contributions from differences among the four positions and if we were to run a test according to this plan, we would have no way of knowing whether differences among tires, or differences among wheels, or both were contributing to the observed value of γ. This plan, then, is unsatisfactory, since it fails to provide a check on the assumption that γ receives no persistent increment from differences among wheels. It appears, therefore, that no test based on one car alone can measure up to our requirements for an acceptable experiment.

If we can use two cars and four tires of each type, a somewhat better plan can be made up. We now have seven degrees of freedom, one of which must be identified with the difference between tires and the one to be so identified is wholly subject to our choice. Let us lay out the seven degrees of freedom with a view to selecting the "safest" one, as is done in Table I.

In making a choice of the component with which to confound the difference between tires, we see that (a) is clearly unsuitable and α, β and γ have already been considered and rejected. The component (a $\times$ α), the interaction of the front-rear difference with cars, may well represent a genuine difference among wheels, because, for example, it is quite possible that front tires wear faster than rear tires on one of the cars, while the reverse holds for the other car. Presumably, then, we would not choose to entangle the comparison between tires with this component. Similar arguments stand in the way of using the component (a $\times$ β). We are left, then, with a component (a $\times$ γ), which represents the second-order interaction between cars, front vs. rear and left vs. right. We cannot, it is true, be certain that this component receives no real contribution from differences between cars and between wheels, but at least it is more likely to be free from such contributions than any of the other components.

TABLE I—Experimental Plan For Testing Tire Wear Using Two Cars

	LF_1	RF_1	LR_1	RR_1	LF_2	RF_2	LR_2	RR_2
(a) Car 1 vs. Car 2	+	+	+	+	−	−	−	−
(α) Front vs. Rear	+	+	−	−	+	+	−	−
(β) Left vs. Right	+	−	+	−	+	−	+	−
(γ) = (a $\times$ β)	+	−	−	+	+	−	−	+
(a $\times$ α)	+	+	−	−	−	−	+	+
(a $\times$ β)	+	−	+	−	−	+	−	+
(a $\times$ γ)	+	−	−	+	−	+	+	−

The allocation of tires to wheels that will confound the difference between types of tire with the component (a $\times$ γ) can be read from the line of Table I that specifies this component, by associating one type with the plus signs and the other with the minus signs. For example, we may put A tires on LF_1, RR_1, RF_2, LR_2 and B tires on the other wheels.

An experiment conducted according to this plan *could* succeed, in the sense that we could have assurance that no persistent differences between wheels have entered into the component that exhibits the difference between types of tire. This would be the situation if, for example, the component (a $\times$ β) proved to contain nothing beyond what experimental error could account for, which would mean that differences between sides are the same on the two cars. In this event, the (a $\times$ γ) component could contain nothing except differences between tires and, of course, experimental error. On the other hand, the plan would fail to give us this assurance if both components (a $\times$ α) and (a $\times$ β) proved to contain substantially more than experimental error. In this circumstance, while we could not assert that the (a $\times$ γ) component did reflect differences among wheels, we could not be sure that it did not.

Evidently, if we desire further insurance against obtaining results which do not furnish a clear-cut and confident interpretation, we shall have to bring more cars into the experiment. Let us suppose that we can equip two more cars with A and B tires in exactly the same arrangement as was used with cars 1 and 2. This amounts to a complete repetition of the experiment envisaged with the first two cars, although it may not be a "replication" in the statistical sense.

When the fifteen degrees of freedom now available are laid out (Table II), it is perceived that only one of the three degrees of freedom which make up the second-order interaction is used to estimate the difference between tires, leaving the other two free to exhibit whatever real interaction there may be. This experiment, then, contains a highly important element, a provision for testing an assumption upon which the interpretation of the experimental results must depend.

One further question must be settled. Every experimental plan must furnish a definition of experimental error and make provision for estimating its magnitude. In the example we are discussing, the definition of experimental error seems to be not wholly obvious. It is proposed that we define experimental error as the content of those second-order interactions which are not confounded with types of tire. The experimental plan based on Table II then furnishes at once a means of estimating the contribution of experimental error. There are, however, only two degrees of freedom designated for this purpose. This number could be increased only by increasing the number of cars.

This definition of experimental error requires that we modify the view that has been adopted up to this point. Throughout the earlier discussion, we took the position that

TABLE II—Experimental Plan for Testing Tire Wear Using Four Cars
The component (a × γ) exhibits the difference between tires A and B. All other components are independent of this difference.

	A LF_1	B RF_1	B LR_1	A RR_1	B LF_2	A RF_2	A LR_2	B RR_2	A LF_3	B RF_3	B LR_3	A RR_3	B LF_4	A RF_4	A LR_4	B RR_4
Between cars																
(a) 1.3 vs. 2.4	+	+	+	+	−	−	−	−	+	+	+	+	−	−	−	−
(b) 1.2 vs. 3.4	+	+	+	+	+	+	+	+	−	−	−	−	−	−	−	−
(c) 1.4 vs. 2.3	+	+	+	+	−	−	−	−	−	−	−	−	+	+	+	+
Between positions																
(α) Front vs. Rear	+	+	−	−	+	+	−	−	+	+	−	−	+	+	−	−
(β) Left vs. Right	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−
(γ) = (α × β)	+	−	−	+	+	−	−	+	+	−	−	+	+	−	−	+
Cars × positions																
(a × α)	+	+	−	−	−	−	+	+	+	+	−	−	−	−	+	+
(b × α)	+	+	−	−	+	+	−	−	−	−	+	+	−	−	+	+
(c × α)	+	+	−	−	−	−	+	+	−	−	+	+	+	+	−	−
(a × β)	+	−	+	−	−	+	−	+	+	−	+	−	−	+	−	+
(b × β)	+	−	+	−	+	−	+	−	−	+	−	+	−	+	−	+
(c × β)	+	−	+	−	−	+	−	+	−	+	−	+	+	−	+	−
(a × γ)	+	−	−	+	−	+	+	−	+	−	−	+	−	+	+	−
(b × γ)	+	−	−	+	+	−	−	+	−	+	+	−	−	+	+	−
(c × γ)	+	−	−	+	−	+	+	−	−	+	+	−	+	−	−	+

some of the differences among cars and among wheels might filter through to the second-order interaction, where we proposed to make our comparison between types of tire, and we were concerned simply to learn whether this did, in fact, happen. For this purpose, the components (b × γ) and (c × γ) were provided. Now, when we propose to use these components to define experimental error, we must take steps in the conduct of the experiment to ensure that no real contributions from differences between cars and wheels reach the second-order interactions. Naturally, this decision places the responsibility for producing a successful experiment on the shoulders of those who carry out the experiment. It is not easy to say just what precautions should be taken to ensure the validity of our definition of experimental error, but it seems reasonable to suppose that we might use cars of the same make and model, check on alignment and wheel balance, control the mileage of the test and the like.

In conclusion, it may be helpful to see the results of a test conducted according to the plan of Table II. Wear was determined by measuring the depths of the two central grooves of the tire by means of a suitable instrument. The analysis of variance results (Table III) were calculated from coded values of such measurements made at the beginning of the test and again after 700 miles of wear.

Table III shows that the arrangement of the experiment did isolate some important sources of variation. Large differences between cars and between front and rear wheels were encountered, and there was some suggestion of an interaction between these two effects—the (between cars × α) component was just short of significance. On the other hand, differences between sides were not important, since neither of the components β and (between cars × β) was significant.

The zero value of the component γ is unusual and must be regarded as accidental. In any event, there is no evidence whatever of an interaction between the front vs. rear and left vs. right components and we may therefore study the components (between cars × γ) and between tires with some confidence that they do not reflect differences between cars or between positions. Consequently the large value of the between tires component may properly be attributed to a real difference between the two types of tire.

TABLE III—Analysis of Variance Results

Source of Variation	Degrees of Freedom	Mean Squares	F*
Between cars			
(a)	1	1668	61.78†
(b)	1	20	—
(c)	1	536	19.85†
Between positions			
(α)	1	751	27.81†
(β)	1	26	—
(γ)	1	0	—
(Between cars × α)	3	489	18.11
(Between cars × β)	3	113	4.19
(Between cars × γ) (error)	2	27	—
Between tires	1	8548	316.59†

*The value in the F column is the ratio of the mean square to the "error" mean square.
†Significance at the 5 percent level.

AUTOMOTIVE TECHNICAL SUPPLEMENT

The Automotive Technical Committee is pleased to announce the publication of the Automotive Supplement No. 1. This booklet, similar to the Textile and Aircraft Supplements, is designed to provide a collection of technical papers which will be of interest to those members in the automotive field.

The Supplement may be obtained by members upon written request to American Society for Quality Control, 50 Church St., New York 7, N. Y. All requests must be in New York prior to Sept. 30, 1954.

Copies of the Supplement will be available to non-members at $1.50 each. The charge of $1.50 will also be made to members requesting more than one copy and to those whose requests are received after Sept. 30.

Application of Statistical Techniques to Standardization of Industrial Products*

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INTRODUCTION

Upon the invitation of the Committee on Statistics in Industry and Technology of the International Statistical Institute, a brief survey was made of the things that have been accomplished in the United States in applying statistical techniques to standardization of industrial products. Many of the gains that have been made during the past decade are of great interest and examples have been selected from the report with usefulness to the quality control profession particularly in mind.

The importance of statistics in standardization has been set forth very clearly by Dr. W. Edwards Deming and his words are quoted as an introduction to the examples of the activities of various standardizing groups:

"Standardization is largely a statistical problem, as good design of experiment and good sampling are necessary in order to derive the best answers, under conditions of actual service, for the sizes, qualities, and terms on which to standardize.

"A standard has no meaning unless an article can be tested by methods that have statistical stability (i.e., show a state of statistical control), are not too costly and are reliable in the statistical sense."

THE AMERICAN SOCIETY FOR QUALITY CONTROL

Although standardization is, perhaps, one of the least widely advertised activities of the American Society for Quality Control, it has had an active Standards Committee since 1947.† The first published standard of the Society, "Definitions and Symbols for Control Charts," ASQC Standard A1-1951, was prepared by the committee in 1951. These definitions are, in general, consistent with those given in the ASTM Manual on Quality Control of Materials which have been in general use in the United States.

The committee reported that its second standard, A2, on "Definition of Terms for Acceptance Sampling" was about ready for publication.

Beyond this, the ASQC has accepted proprietary sponsorship of the American War Standards Z1.1, Z1.2 and Z1.3 on Quality Control. A consensus of industrial opinion is being secured regarding the adoption of these as full American Standards by the American Standards Association.

It is to be noted that these are all statistical standards whereas the ASTM and some industry associations have been moving more along the line of adopting standard statistical clauses in material standards.

Another related activity of the ASQC is the publication of a class of general publications. The first of these, "Manual on Sampling Inspection by Military Standard, MIL STD 105-A," was published in 1953. An interesting fact about this manual is that it was prepared under the auspices of a Joint Committee of the ASQC and of the National Screw Machine Products Association.

THE AMERICAN SOCIETY FOR TESTING MATERIALS

One of the most active societies engaged in standardization is the American Society for Testing Materials. It has a committee organization based on the various materials of industry. Many of these committees have sub-committees interested in the statistical aspects of testing or of specification. Still others carry on more or less statistical work on an informal basis.

Material Committees

Some examples of the consideration being given to statistical methods show a very rudimentary approach to a sound statistical basis; others are quite sophisticated. Most new methods emanating from Committee D-19 on Industrial Water, for example, contain some precision and accuracy statement. However, in the "Proposed Method of Test for Odor of Industrial Waste Water," the statement is simply:

"The precision and accuracy of this method depend on the material producing the odor, and on the physical condition, experience, and skill of the operator."

In contrast, another standard of this committee, "Revised Tentative Methods of Test for Hardness in Industrial Water," ASTM Designation D1126-T, provides a very clear definition of the precision and accuracy to be expected, as follows:

> *"Precision and Accuracy*
>
> (a) Results for the total calcium and magnesium hardness and for the calcium hardness should be reproducible to within 0.1 ppm or 1 percent of the amount present, whichever is the greater.
>
> "(b) The method is accurate to within 0.04 ppm or 1 percent of the total hardness present, whichever is the greater, in the absence of interfering ions in excess of the amounts shown in the table (not reproduced) and in the hardness range of 0.10 to 24 ppm. The method is accurate to within 0.004 ppm of the total hardness present in the absence of interfering ions in excess of the amounts shown in the table and in the hardness range of 0 to 0.10 ppm. The determination of calcium hardness is accurate to within 0.04 ppm or 2 percent of the calcium hardness present, whichever is the greater."

Another forward-looking practice of the same committee is the publication of supporting data relating to new and revised methods of testing as appendices to its reports. An example from the last mentioned method is given in Table I.

*Abstracted from a report of the same title presented at the 28th Session of the International Statistical Institute, Rome, September 1953.

†The present personnel of this committee are: Harold F. Dodge, Chairman; Irving W. Burr, Eugene L. Grant, and Ralph E. Wareham.

TABLE I—Typical Determination of Total Hardness by Non-Referee Method A of Method D1126—Precision Study

SAMPLE NO. 1—DILUTED CLEVELAND CITY WATER

Total Hardness, ppm $CaCO_3$

	Analyst A	Analyst B
1	29.5	29.8
2	29.5	29.5
3	29.4	29.8
4	29.3	29.4
5	29.4	29.2
6	29.5	29.4
7	29.4	29.2
8	29.5	29.3
9	29.4	29.2
10	29.5	29.2
Average	29.44	29.40
Std. Dev.[10]	0.06	0.22
Std. Dev.[20]	0.17	

Precision: 0.57 percent of hardness present

Other committees have similar activities under way, notably Committee E-2 on Emission Spectroscopy, Committee B-1 on Wires for Electrical Conductors, Committee D-2 for Petroleum Products and Lubricants, and Committee D-13 on Textile Materials.

Committee D-2 has published, for example, "Recommendations on the Form of ASTM Methods of Test for Petroleum Products and Lubricants" and, in 1953, "Proposed Recommended Practices for Applying Precision Data Given in ASTM Methods for Test of Petroleum Products and Lubricants."

Committee D-13 has published, "Recommendations on the Form of ASTM Methods of Test for Textile Materials" and "Tentative Recommended Practice for Interlaboratory Testing of Textile Materials." As an example, the precision and accuracy statement from the "Tentative Methods of Test for Abrasion Resistance of Textile Fabrics, Oscillatory Cylinder Method," ASTM Designation D1175-51T, is given below:

"(a) *Repeatability* (Inherent Reproducibility) — Averages of 16 residual breaking strength measurements made by one operator on a single tension testing machine on cloth abraded upon the machine shall be within 5 percent of its material average with a probability of 95 percent. The percentage loss in breaking strength of averages of 16 measurements made by one operator on a single tension testing machine on cloth shall lie within 6 percent of its material average with a probability of 95 percent. The material average for any one machine-operator combination for practical purposes is the average of 25 or more measurements, if the machine is in statistical control as determined by standard chart techniques.

"(b) *Reproducibility* (Over-all Reproducibility) — Residual breaking strength averages of 16 residual breaking strength measurements made by one operator on a single tension testing machine on cloth abraded upon more than one machine (each machine having a different operator) shall be within 5 percent of the grand average with a probability of 95 percent. The percentage loss in breaking strength of averages of 16 measurements made by one operator on a single tension testing machine on cloth abraded upon more than one machine (each machine having a different operator) shall be within 20 percent of the grand average with a probability of 95 percent. The grand average for practical purposes shall be the over-all average of the material averages from three or more laboratories, material averages as defined in Paragraph (a)."

The purpose of the report made at Rome was to present a factual account of the trend toward more sophisticated statistical usages in standards in the United States. Although the presentation was non-critical, the ASTM examples, in particular, were so chosen as to show a gradually increasing awareness of the need for more explicit statistical treatment of data and for clearer definition of terms. For example, although the clarity of the precision and accuracy statement in the Test for Hardness of Industrial Water may leave something to be desired, it is a decisive improvement over the statement in the Test for Odor of Industrial Waste Water. Similarly, although the data of Table I suggest that a real measure of precision is not possible from the data presented because of the numerous duplications in the readings, nevertheless, the fact that the original data have been published at all represents some kind of a triumph for the proponents of statistics.

The satisfactory definition of terms such as "repeatability" and "reproducibility" is difficult because, in every specific application to testing of a material, a concept that is quite generally applicable must be restricted in some way. This anomaly has resulted in considerable criticism of the attempts of the materials committees to define precision and accuracy requirements closely. The criticism is due, generally, not to misuse of statistics, but to the failure to state clearly the restrictions on the definitions. For example, the definitions published by Committee D-13 should probably have some qualifying designation, such as "D-13 Repeatability," "D-13 Reproducibility," and so forth.

There are two observations arising from the preparation and presentation of the Rome report that should possibly be made:

1—By and large, those involved in the writing of standards are well aware of the need for better statistical data and are appreciative of constructive criticism.

2—The standardizing agencies in the United States appear to be ahead of their European counterparts in their understanding and use of modern statistical techniques in the preparation of standards.

Committee E-11 on Quality Control of Materials

This committee of ASTM is concerned primarily with assisting the materials committees in recognizing the need for and using statistical methods in the preparation of standards. Its "Manual on the Presentation of Data,"* recently revised and reissued as the "ASTM Manual on Quality Control of Materials,"* is well known. So also, is the "Recommended Practice for Designating Significant Places in Specified Limiting Values," ASTM Designation E-29-50.

This committee has a number of task groups at work on different statistical problems related to standards such as sampling plans, planning interlaboratory test programs, the number of tests for a desired precision of an average, bulk sampling, smoothing empirical data, definition of precision and accuracy, and the design of experiments.

A new subcommittee of E-11, Subcommittee No. I on ASTM Problems, is in the process of being organized. It will be made up of representatives of E-11 and of other materials committees of ASTM. It will try to bring more rapid and effective attention to problems of the materials committees which involve statistical methods.

Other ASTM Statistical Activities

From time to time ASTM Symposia have had considerable content of a statistical nature. Some of the principal papers in Symposia which have appeared since 1947 are listed in the "References."

*See "References" at the end of this article.

THE AMERICAN STANDARDS ASSOCIATION

The American Standards Association in general approves standards only when proposed under the sponsorship of other technical societies. Nevertheless, its wartime sponsorship of the Z1.1, Z1.2 and Z1.3 standards was an exception which provided one of the greatest forces in fostering the wide spread of the use of statistical quality control and which greatly influenced the formation of ASQC.

The Canadians and Japanese have adopted these as national standards in their countries and Z1.1—Z1.2 has been adopted as a British Standard. The sale of 22,000 copies of Z1.1—Z1.2 and over 38,000 copies of Z1.3 is a clear indication of the influence of these standards.

The ASA has also been the instrument in arousing United States interest in the work of Committee TC-69 of the International Standardizing Organization. Progress is being made toward formation of a committee including representatives, among others, from the ASA, ASQC, ASTM, and the Institute of Mathematical Statistics.

INDUSTRIAL STANDARDS

An Electronics Industry Standard

The Joint Electron Tube Engineering Council representing the Radio and Television Manufacturers Association (RTMA) and the National Electrical Manufacturers Association (NEMA) has a subcommittee, JTC-11, on Sampling Procedures. This subcommittee published in 1953 a "Glossary of Quality Control Terms" which is effectively an industry standard.

Statistical Sampling Plans and Specifications

A number of the most progressive manufacturing concerns apply statistical concepts to the sampling aspects of purchase specifications. For example, in specifying natural rubber rings for transite pipe, the Johns-Manville Corporation not only specifies the samples to be provided for the purpose of specific physical tests, but also calls for a report on all applicable routine test data on the batches of compound from which rings were shipped.

Likewise, the durometers used to measure hardness of the compound both by the J-M quality control laboratories and by the vendor are compared with reference standards in the J-M research laboratory.

Similarly, statistical considerations are entering into purchasing standards of other companies. It is inevitable, due to the great growth in the use of statistical quality control techniques in industry, that there should have grown a concomitant interest in the spread of the statistical concepts to standards of all sorts. This process is well under way in United States industry.

THE ARMED FORCES

Military standard sampling plans have, of course, been in wide use since the early 1940's. MIL-STD 105-A, "Sampling Procedures and Tables for Inspection by Attributes," has received wide application.

More recently, NAVORD Std. 80, a variables sampling plan based on the range, has been available, as well as NAVORD Std. 81, a variables sampling plan based on the continuous sampling plans of Dodge.

A new MIL-STD, "Sampling Procedures and Tables for Inspection by Variables," is in preparation at Stanford University. It is expected that this will present plans based both on the range and on the standard deviation.

CONCLUSION

There is much food for thought in the words of W. J. Harris, Jr., Executive Secretary of the National Academy of Science's Minerals and Metals Advisory Board speaking at a meeting of the ASA Standards Council in April, 1953.

Mr. Harris presented his concept of standards as the end product of research. He pointed out that until 1941 or 1942, the bulk of research had been done in producers' and consumers' laboratories and that its results were transferred directly to the working standards committees.

Now, we are engaged to a large extent in government research in new, complex technical fields which pose design concepts and materials problems far beyond any older civilian counterpart. For example, Mr. Harris pointed out, available analysis methods for titanium sponge are time consuming, complex, and incompletely standardized. New specifications are needed complete enough to define a grade of sponge suitable for future as well as present needs and producible under present technology. To do this, statisticians, working with existing standardizing agencies, must interpret and apply the results of the new research which is largely armed forces research.

We agree with his conclusion that standards are not dead, but rather, living, growing concepts. They feed, as he says, on new data and any failure of the system which provides the data is reflected in a stunted or inadequately nourished standard.

APPENDIX

Sources of Standards

American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

American Society for Quality Control, 70 E. 45th Street, New York 17, N. Y.

American Standards Association, 70 E. 45th Street, New York, N. Y.

Superintendent of Documents (Military Standards), U. S. Government Printing Office, Washington 25, D. C.

Johns-Manville Corp., Quality Control Department, 22 E. 40th Street, New York, N. Y.

Joint Electron Tube Engineering Council, c/o Mr. J. R. Steen, Sylvania Electric Products, Inc., 1740 Broadway, New York, N. Y.

National Bureau of Standards, Washington 25, D. C.

References to ASTM Publications

1946 ASTM Manual on Presentation of Data, STP 15-B.

1946 "Discussion on Statistical Quality Control in its Application to Specification Requirements"; (a) "Use of Statistics in Writing Specifications," Caspar Goffman and Joseph Manuele; (b) "Dollars for Your Thoughts," Leslie E. Simon.

1947 "Symposium on Rubber Testing," STP 74. The papers in this symposium stress the importance of standardization in the rubber industry: (a) "Developments and Improvements in Methods of Stress-Strain Testing," J. W. Schade and F. L. Roch; (b) "Standardization of Testing and Inspection in Government Rubber Plants," Ludwig Meuser, Robert D. Stiehler and R. W. Hackett; (c) "The Use of Statistical Methods in Rubber Evaluation," Marian M. Sandomire.

1943 "Symposium on the Usefulness and Limitations of Samples," ASTM Proceedings, V. 48; (a) "Sampling and Its Uncertainties," S. S. Wilks; (b) "On Variation in Materials, Testing, Sample Sizes." Leslie E. Simon; (c) "The Amount of Inspection as a Function of Quality Control," G. R. Gause.

1949 "Symposium on Application of Statistics," STP 103; (a) "The Economic Relationship Between Design and Acceptance Specifications," Eugene L. Grant; (b) "Precision and Accuracy of Test Methods," Grant Wernimont; (c) "Use of Statistics to Determine Precision of Test Methods," W. J. Youden and J. M. Cameron.

1951 "Symposium on Bulk Sampling," STP 114; (a) "Materials Handling for Bulk Sampling," Joseph Manuele; (b) "Economic Accumulation of Variance Data in Connection with Bulk Sampling," Louis Tanner and Melvin Lerner; (c) "Two-Stage Acceptance Sampling by Attributes," C. W. Dunnett and J. W. Hopkins; (d) "Coal Sampling Problems," A. A. Orning; (e) "The Analysis of Variance in a Sampling Experiment," W. M. Bertholf; (f) "The Design of Coal Sampling Procedures," W. M. Bertholf.

1951 "Symposium on Statistical Aspects of Fatigue," STP 121; (a) "Planning and Interpretation of Fatigue Tests," Alfred M. Freudenthal; (b) "On the Statistical Nature of Fatigue," Foster D. Stulen; (c) "Statistical Analysis of Fatigue Data," Robert Plunkett.

1951 ASTM Manual on Quality Control of Materials, STP 15-C.

1952 "Symposium on Statistical Methods for the Detergent Laboratories," STP 139; (a) "Graphical Methods of Statistical Analysis and Tests for Significance," P. L. Schmidt; (b) "The Design of Laboratory Control of Laundry Washrooms Based on an Analysis of Variance," George S. Freeman and Morris I. Cohn; (c) "The Importance of Correlations in Detergence Testing," Joseph M. Lambert and Edward J. Leshan.

Bibliography

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ANALYSIS OF VARIANCE

SOME SELECTED QUICK AND EASY METHODS OF STATISTICAL ANALYSIS, John W. Tukey, Princeton University, Princeton, N. J.

(Transactions New York Academy of Sciences—v. 16, Ser. II, p. 88

This article discusses in great detail the analysis of variability within groups of measurements and between groups of measurements. The problem is presented in terms of single groups of measurements, two groups of measurements and several groups of measurements. The range is used in place of standard deviation for what are essentially analysis of variance techniques. Additional more complicated classifications such as an unbalanced double classification, irregularities in a double classification and analysis of interaction. Numerous tables enabling the reader to use the range in these tests for analysis of differences are given. Illustrated with examples.

APPLICATION—CHEMICAL INDUSTRY

B—STATISTICAL DESIGN

(Ind. and Eng. Chemistry—v. 45, n. 11, Nov. 1953, p. 65A)

This editorial describes the growth of interest in statistical methods with respect to chemical engineering activities. Some of the meetings and literature in the field are noted. The interest of the editors in helping advance knowledge in this field is expressed.

APPLICATION—METALLURGICAL INDUSTRY

SYMPOSIUM ON THE CONTROL OF QUALITY IN PRODUCTION OF WROUGHT NONFERROUS METALS AND ALLOYS, 2. Control of Quality in Working Operations.

(Journal of the Institute of Metals—v. 82, pt. 7, Mar. 1954, p. 281)

This second group of articles discusses control of quality in working operations, whereas the first of this series discussed the control of quality in melting and casting. The first symposium issue was reviewed in the September 1953 Bibliography, and was the March 1953 issue of the *Journal of the Institute of Metals*. The March 1954 issue includes the following articles:

"Control of Dimension, Shape, and Finish in Rolling of Sheet and Strip and in Drawing of Wire," H. Ford, J. G. Wistreich

"Control of Quality in Hot and Cold Rolling of Aluminum and Aluminum Alloys," F. King, A. N. Turner

"Control of Properties and Structure in Hot and Cold Rolling of Copper and Copper-Base Alloys," W. W. Kee

Selected references in the Bibliography of *Industrial Quality Control* are obtained from the following sources:

The International Statistical Institute, *International Journal of Abstracts on Statistical Methods in Industry.*

The Chemical Division, ASQC.

The Statistical Committee, TAPPI.

BRYANT GROOVE GAGE

This Bryant gage checks the diameter and roundness of internal grooves up to 5". Four sets of segments are adjustable to cover the range of standard "O" ring grooves and four different sets are adjustable to cover the range of snap ring grooves. A movable segment actuates the dial indicator which gives direct reading of any variation from basic size.

Bryant Chucking Grinder Co., Springfield, Vermont, U. S. A.

"Factors Affecting Quality of Extrusions," C. Smith and N. Swindells

"Statistical Control in Metal-Working Operations," M. Whyte

APPLICATION—TEXTILE INDUSTRY

POSSIBILITIES FOR SYSTEMATIC CONTROL IN WOOL YARN PRODUCTION, G. H. Thorndike and A. Brearley
(Journal of the Textile Institute—v. 44, n. 12, Dec. 1953, p. P794)

This article discusses many of the factors and techniques necessary to control quality of wool yarn. In addition to the technical methods and problems, the graphical presentation of data and the use of statistical and quality control is included as an important application of testing results and records.

APPLICATION—METAL WORKING

TRIAL TECHNIQUE FOR QUALITY CONTROL,
(Steel—v. 134, n. 2, Jan. 11, 1954, p. 92)

Random sampling of machines was used at Roylyn Inc., Glendale, California, for a trial run to determine applicability of in-process quality control. Examples of application of this approach given. Sampling tables and classification of defects also discussed.

APPLICATION—MISCELLANEOUS

THE FUNDAMENTALS OF CONTROL CHARTS, Charles A. Bicking, Office, Chief of Ordnance, Washington, 25, D.C.
(TAPPI—v. 36, n. 12, Dec. 1953, p. 544)

A major problem to be overcome is the rational sub-grouping of data to arrive at appropriate limits for the control chart. The choice of grouping depends on more information about the sources of variation in paper quality than is usually on hand. This lack is being overcome as more is learned about the variability of paper testing and sampling techniques. New types of measurement devices are helping to accumulate the basic variation information needed for intelligent chart control. Inherent in the success of any plan of control is a method for obtaining positive action to correct causes of lack of control as they occur. Limits must be established on "economic" bases and supervision must be ready to make changes upon the advice of the quality control engineer. Finally, if the charts are intended as a means of currently controlling the output of a paper machine, they must be simple enough for any operator to use and understand. The advantages of the quality control program must be kept before the whole organization as constantly as any other important program, such as safety.

CONTROL CHART FOR NEWSPRINT WEB BREAKS, S. Steinberg, New York Times, New York.
(TAPPI—v. 37, n. 2, Feb. 1954, p. 40A)

Part 1. Newsprint is supplied by six mills. A control chart for the fraction defective for each is plotted by weeks. A "defective" is defined as a roll that breaks one or more times. Three sigma limits are used for judging out-of-control points. The latter are reported as promptly as possible to the mills that they may look for assignable causes for the variations. Mills may be "in control" but still maintain an average level high enough to interfere with pressroom schedules and production. Then, a mill "in control" at too high a level must make changes to lower that level.

Part 2. A simple illustration of the value of statistics in showing the existence of a correlation. It was calculated, for the same six mills, that the use of 100 percent supply by one mill would produce an average of about 2.85 percent waste (not including wrappers or damage beyond the pressroom); whereas, the use of 100 percent supply by the other five mills in their present proportions would produce an average of 3.74 percent waste.

ENGINEERING AND EXPERIMENTS

HOW DESIGN QUALITY CONTROL CAN HELP ENGINEERING, Charles E. Ellis, Director of Quality Control, Ford Instrument Co., Division of The Sperry Corp., Little Neck, N. Y.
(Transactions of the I.R.E., P.G.E. M-1, Feb. 1954)

Quality Control supplies to the design engineer important information not ordinarily available. Simple statistical quality control techniques can adequately evaluate the effectiveness of design as well as establish realistic tolerances and specifications. To enable engineering to take advantage of statistical quality control, certain requirements are set forth. These include first top management's firm support for quality control is one phase; the function of quality control in recognizing problems of tolerances and designs is also indicated; the use of material review boards, design quality control committees; and the providing of detailed reports of machine capabilities and production performance.

A STATISTICAL ANALYSIS OF ICING - FLIGHT OBSERVATIONS, Emile Z. Gilutin, Assistant Project Engineer, American Airlines, Inc., Flushing, N. Y.
(Journal of the Aeronautical Sciences—v. 20, n. 11, Nov. 1953, p. 856)

This is a brief report of an investigation. In it, icing flight data were examined through the use of statistical methods. An equation correlating temperature of liquid water content, and water droplet diameter was developed. Prediction of temperature of icing in terms of a probability are given.

SETS OF THREE MEASUREMENTS, W. J. Youden, National Bureau of Standards, Washington, D. C.
(The Scientific Monthly—v. 77, Sept. 1953, p. 143)

The experimenter must decide prior to his measurements what degree of difference he is interested in detecting. This paper discusses the means of reducing the zone of uncertainty by devoting attention to obtaining a good estimate of the errors. It is necessary to set up some operating rule to warn the experimenter that one of the measurements may be subject to an error which is not usually associated with the procedure.

FIVE EXAMPLES OF DESIGNED EXPERIMENTS IN INDUSTRY, Charles A. Bicking, Office, Chief of Ordnance, Washington 25, D. C.
(TAPPI—v. 37, n. 2, Feb. 1954, p. 40A)

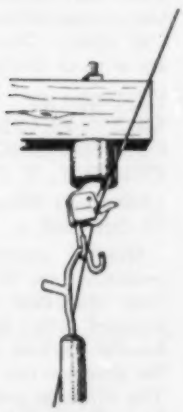
The pole that need not be climbed

Fastening wires with new tool.

Since telephony began, there has been just one way to install telephone wires on poles: have a trained man climb up and fasten them there. Now Bell Laboratories engineers have developed a special pole line for rural areas. The entire line can be erected without climbing a pole.

The whole job is done from the ground. Light-weight poles are quickly and easily erected. Newly created tools enable men to fasten wires to crossarms 10 to 25 feet over their heads.

This inexpensive line promises more service in sparsely populated places. From original design to testing, it exemplifies a Bell Telephone Laboratories team operation in widening telephone service and keeping costs down.



Key to the new "climbless" pole is this insulator. Ground crews use long-handled tools to place the wire in position and then lock it fast.

Bell Telephone Laboratories

IMPROVING TELEPHONE SERVICE FOR AMERICA PROVIDES CAREERS FOR CREATIVE MEN IN SCIENTIFIC AND TECHNICAL FIELDS

This paper is written from the point of view that in most of its industrial uses statistics is an experimental tool. An outline is given of experimental procedure when it involves statistical design of experiment. Paper industry applications are described which emphasize the experimental aspects of accumulating data in industry. Five examples cover the design of control charts for process control; the use of significance tests to determine whether the two gages of a Mullen tester read the same; an experiment to determine whether four thermometers read alike; an experiment to determine whether analysts or the thermometers themselves are the causes of variability; and a complex experiment to determine the effect of varying four processing factors on photovelt brightness after a multistage bleach.

MANAGEMENT & PERSONNEL, GENERAL

QUALITY CONTROL, HOW MUCH INSURANCE SHOULD YOU BUY—HOW MUCH CAN YOU AFFORD?

(Production—v. 34, n. 2, Aug. 1954, p. 109)

The problem of justifying the cost of quality control in terms of benefits derived is discussed at a round table meeting. This article presents the discussions and the opinions of the various individuals taking part. The point is stressed that constant inspection or control usually is an indication that additional work should be done on the process to improve its mechanical ability. General use of quality control discussed.

IMPORTANT MANAGEMENT HELP: PLANNED PROGRAM FOR PERSONNEL QUALITY CONTROL, T. J. Wright

(Advanced Management—v. 18, n. 10, Oct. 1953, p. 17)

Quality control program for personnel can be set up. This article discusses what should be covered, what department should handle various aspects and how the program can be made to work. The ultimate goal of this program is to develop for the company a staff of competent dependable employees.

QUALITY CONTROL RATES RAW MATERIAL, W. A. MacCrehan, Bendix Radio, Inc., Towson, Md.

(TAPPI—v. 37, n. 2, Feb. 1954, p. 40A)

In today's competitive market, the converter of paper to a printed product cannot afford to be unconcerned for the level of quality of the raw materials flowing into his finishing operation. Through planned statistical routings many costly variables can be isolated from usable material. This is accomplished through a four-step plan: 1. Knowing the *real* problem through statistically collected facts —not through opinions. 2. Getting together with vendors to advise them of a quality program. 3. Recognizing that papermaking is an "art" that is slowly becoming a "science" through the progress of measuring variation. 4. Sticking to basic problems. The control of raw material by graphic statistical methods can build finer products. Three points are vital—first, common sense in working out problems with your supplier; second, internal strength by your own management in being objective in their relations with vendors; and finally, selling the program thoroughly within your own plant before dealing with vendors.

SAMPLING PLANS & RELATED TOPICS

ACCEPTANCE SAMPLING OF ELECTROPLATED ARTICLES, J. M. Cameron, and F. Ogburn

(Plating—v. 41, n. 1, Jan. 1954, p. 43)

The use of a sampling plan for electroplated coatings is discussed. Coatings are inspected and classified on the basis of thickness of coating, adhesion, salt spray resistance and appearance. The operating characteristics and the selection of an acceptance sampling plan are discussed. The selection of samples from a lot is also considered.

TABLES

SOME USES OF NOMOGRAM IN STATISTICS, S. Broadbent

(Applied Statistics—v. 3, no. 1, Mar. 1954, p. 33)

A discussion of the theory of nomograms and the construction of simple nomograms, several of which apply to statistical methods used in quality control. These include a nomogram for confidence limits of the mean and a nomogram for the comparison of two means. Examples of the applications of such charts to specific problems are given.

STATISTICS

NEW LIGHT ON THE CORRELATION COEFFICIENT AND ITS TRANSFORMS, H. Hotelling

(Royal Stat. Soc. Journal—v. 15, n. 2, 1953, p. 193)

SOME RESULTS IN SAMPLING THEORY WHEN THE UNITS ARE SELECTED WITH UNEQUAL PROBABILITIES, J. Durbin

(Royal Stat. Soc. Journal—v. 15, n. 2, 1953, p. 262)

USE OF RUNS TO CONTROL THE MEAN IN QUALITY CONTROL, H. Weiler

(Am. Stat. Assoc. Journal—v. 48, Dec. 1953, p. 816)

MATHEMATICAL BASIS FOR THE BEAN METHOD OF GRAPHIC MULTIPLE CORRELATION, R. J. Foote

(Am. Stat. Assoc. Journal—v. 48, Dec. 1953, p. 778)

ON THE EQUIDISTRIBUTION OF SUMS OF INDEPENDENT RANDOM VARIABLES, H. Robbins

(Am. Math. Soc. Proceedings—v. 4, Oct. 1953, p. 786

SOME NOTES ON THE APPLICATION OF SEQUENTIAL METHODS IN THE ANALYSIS OF VARIANCE, N. L. Johnson

(Annals of Math. Stat.—v. 24, Dec. 1953, p. 614)

RICHARD VON MISES' WORK IN PROBABILITY AND STATISTICS, H. Cramer

(Annals of Math. Stat.—v. 24, Dec. 1953, p. 657)

ON A GENERALIZATION OF CLASSICAL PROBABILITY THEORY. MARKOFF CHAINS, R. Bellman

(National Academy of Science, Proceedings—v. 39, Oct. 1953, p. 1075)

CLOSURE CLASSES ORIGINATING IN THE THEORY OF PROBABILITY, S. Bochner

(National Academy of Science, Proceedings—v. 39, Oct. 1953, p. 1082)

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to Meet Every Quality Control Requirement

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THE L. S. STARRETT COMPANY, ATHOL, MASSACHUSETTS, U. S. A.

FOR TESTNG AN UNKNOWN PROBABILITY, J. deBoer

(Applied Scientific Research—v. 3B, n. 4-5, 1953, p. 249)

OPERATIONS RESEARCH

OPERATIONS RESEARCH, Robert Loeffelbein, General Electric Co., Hanford Atomic Products Operation.

(Supervision—v. 16, n. 6, June 1954, p. 18)

Operations research techniques and the "team" system can be applied to business problems with huge savings possible. Areas of application include the problems related to inventory control, production scheduling, etc. Details of methods are not given.

OPERATIONS RESEARCH, P. M. Morse

(Applied Mechanics Reviews—v. 7, n. 3, Mar. 1954, p. 89)

Operations research is defined in terms of its application of research techniques. Industrial as well as military operations are included. The use of statistical techniques and probability as well as many other disciplines are included. A few of the basic conceptions such as linear programming are explained. Among others are the concepts of "bounded optimization" in industry.

REPORTED—NOT REVIEWED

STUDY OF THE LIVES OF POTS USED IN MAKING GLASS, J. Keen and D. J. Page

(Applied Statistics—v. 1, Nov. 1952, p. 163)

ACCURACY OF SAMPLING COAL, J. Hebden and G. H. Jowett

(Applied Statistics—v. 1, Nov. 1952, p. 179)

THE STATISTICAL ASPECTS OF RELIABILITY, Robert Lusser, Guided Missile Reliability Coordinator, Los Angeles Ordnance District, Los Angeles, Calif.

(Electronic Applications Reliability Review—n. 2, Nov. 1953, p. 13)

ON THE RELIABILITY OF COMPLEX SYSTEMS, Maj. Gen. Leslie E. Simon, Assistant Chief of Ordnance, Washington, D. C.

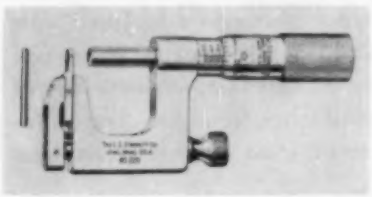
(Electronic Applications Reliability Review)—n. 2, Nov. 1953, p. 5)

What's New?

ROY A. WYLIE, *Editor*

News releases describing new products and literature should be sent to:

George R. Foster, Mng. Ed.
Room 6123 Plankinton Bldg.
161 W. Wisconsin Ave.
Milwaukee 3, Wis.



The "MUL-T-ANVIL" micrometer, featuring multiple interchangeable anvils, is now available from the **L. S. Starrett Company,** Athol, Mass. The micrometer is designed to permit quick, accurate measurement of tubing, cylindrical walls, from holes or slots to an edge and in hard-to-reach locations. It may be used with one of the two anvils furnished or with anvils of special shapes which can be made quickly. Change-over of anvils for different measuring jobs is accomplished by placing the desired anvil in the frame vise and tightening the locking screw. The micrometer can also be used as a height gage by simply removing the clamping vise jaw. Range is 0 to 1 inch by thousandths.

★ ★ ★

A completely automatic, hopper-fed, electronic gage to measure the overall length and outside diameter of highly polished cylindrical roller bearings and sort them into 12 classifications of .0001" each, plus scrap and salvage, is announced by **Federal Products Corp.,** 1144 Eddy Street, Providence, R. I. The gage

operates at a rate of 6,000 to 8,000 roller bearings per hour and can be quickly adjusted to handle bearings with diameters and lengths ranging from 3/16" to ⅝". From a vibrating type hopper the workpieces drop down a feed chute to a platen, where they are fed into a rotating carrier wheel which carries them to the diameter and length gaging stations. Diameter and length are measured by two electronic gage heads and through amplifiers, the measurement is set in the mechanical memory located beneath and keyed to the carrier wheel. When the workpiece is above the correct disposal chute, the mechanical memory causes a lever to be released, opening the trap door and dropping the workpiece into a tote box below. All timing, measuring and recycling of this Electronic Gage is controlled by timing cams and microswitches located at the base of the memory unit.

★ ★ ★

Bausch & Lomb, 635 St. Paul Street, Rochester, N. Y., announce a combination colorimeter and spectrophotometer which produces high wavelength accuracy and spectral purity through use of a diffraction grating. It offers flexibility and a high degree of accuracy to research and quality control people concerned with the more complex analysis of spectrophotometry. Called the Spectronic 20 because of its 20 mmu band pass, the instrument is designed for speedy, simple opera-

power in a package by SORENSEN

THREE PRECISION POWER SUPPLIES IN ONE CABINET, TO HANDLE ALL OF YOUR LABORATORY POWER REQUIREMENTS.

This newest Sorensen concept—*Power in a Package*—is designed to give the research man, technician, or designer a wide range of power outputs, all from one compact cabinet.

The unit illustrated will provide regulated power, simultaneously, as follows: 0-600 volts DC at 0-500 mils, regulated ±0.25%; 6 or 7 volts DC at 1.5-15 amps, regulated ±0.2%; 110-120 volts AC, 0-1000VA load range, regulated ±0.1%.

Many *packaged power* variations are possible, depending on requirements. Practical combinations can include any of the following instruments.

AC Regulators	High-Current DC	High-Voltage DC
150VA	6-7 v @ 5, 15, 40 amps	0-325 v, 0-125 ma
250VA	12 v @ 5, 15 amps	0-500 v, 0-200 ma
500VA	28 v @ 5, 10 amps	0-500 v, 0-300 ma
1000VA	6/12 v @ 5/10 amps	0-600 v, 0-500 ma
2000VA		Dual 350 v to 60 ma
3000VA		
1000VA at ±0.01% reg.		

In addition, *±0.01% frequency control in an auxiliary unit: 400 cycles at 250VA or 1000VA; 60 cycles at 1000VA.*

Consult our engineers for other power packages, comprising such instruments as Rangers, AC meter calibrators, DC voltage reference standards, inverters, higher capacity regulators and power supplies than those indicated above. Sorensen & Co., Inc., Stamford, Conn. In Europe, Sorensen A.G., Gartenstrasse 26, Zurich 2, Switzerland.

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Attach to your business or professional letterhead

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Sorensen & Co., Inc., 375 Fairfield Ave., Stamford, Conn.

tion by laboratory technicians who need use only two control knobs in making routine colorimetric analyses. An illustrated brochure, Catalog D-266, describing the instrument in detail is available from the manufacturer.

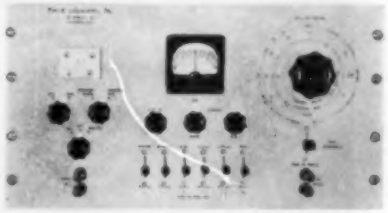
★ ★ ★

A bench center especially designed for inspecting miniature parts is manufactured by the **Transicoil Corp.**, 107 Grand Street, New York, N. Y. It measures 9" x 5⅞" x 1⅛" at the base, and its features are: one-hand adjustment of the live center post; removable live and dead centers; replacable spring; and easily regulated sliding fit of live center. The base is ground on all sides, permitting a wide variety of set-ups and checking in all planes. The weight is 16½ pounds.

★ ★ ★

A production gaging instrument that inspects four dimensions simultaneously on the carrier body of an automatic transmission is manufactured by **The Sheffield Corp.**, Dayton 1, Ohio. In one operation, an unskilled operator can check the seat chamfer on the inside of the body, outside body diameter, overall body length, and the dimensions from the top of the shank to the bottom edge of the upper flange. Dimensional quality of the part is indicated by a master light and four individual signal lights on the diagram panel. When all dimensions are in tolerance, the master light remains white and the four signal lights on the panel black out. If one or more dimensions are out of tolerance, the master light turns red and the signal lights indicate the faulty dimensions by turning either red or green to indicate undersize or oversize. Lights of the correct dimensions black out. The instrument is equipped with three new small Electricheck Gage Heads for checking outside dimensions. An Airlectric Gage Head checks the internal seat chamfer. The gage is set up with maximum and minimum masters.

★ ★ ★



A new transistor test set, Model GP 1, has been announced by **Baird Associates, Inc.**, 33 University Road, Cambridge 38, Mass. It is designed as a versatile laboratory instrument or for routine production testing. NPN and PNP type transistors may be tested in either grounded base or grounded emitter configuration. Coefficients are read directly and include Hybrid, Equivalent "T" and "Black Box" parameters, alpha cutoff, collector capacitance and I_{co}, as well as current gain and voltage feedback ratio. The test set is used in conjunction with an external oscillator and vacuum tube voltmeter of types commonly used in electronic laboratories. Provision is made for measuring phase angle as well as magnitude of the hybrid coefficients, thus permitting accurate design of AF, IF and RF circuits.

★ ★ ★

DoALL MONOLIGHTS
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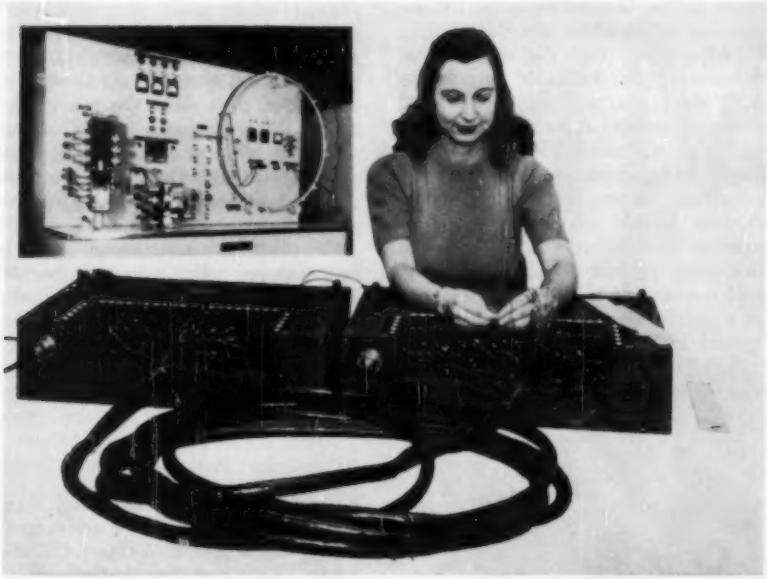
for use with Optical Flats
Millionths-inch measurement of flatness, size, parallelism
5" also covers 14" working area.
• Powerful light creates sharp fringe lines.
• Head turns 180°, removable
• Lightweight, portable case
• Three Sizes 2" - 5" - 20"
Also
See one at your plant—See classified directory for your local DoALL Service-Store with complete stocks of gages and metalworking necessities.
Immediate delivery from local stock
Call Your DoALL Service-Store
Machine Tools
Cutting Tools
Measuring Instruments
Shop Supplies
In Stock
The DoALL Company, Des Plaines, Ill.

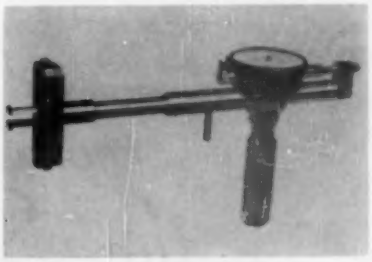


A new Cable Inspector has been announced by **PANASCAN, Division of Panellit, Inc.,** 7401 N. Hamlin Avenue, Skokie, Ill. This unit automatically performs a number of operations ordinarily laboriously done by hand in a small fraction of the time usually required. The Inspector is adaptable to quality control of prefabricated harnesses and cables for radar components, aircraft, automatic fire control conductor cable (100 circuit maximum). The Inspector automatically checks insulation resistance of each conductor to every other conductor and of each to ground. Faults are detected by DC bridge circuits, using vacuum tubes and relays as sensing devices. Resistance acceptance limits are adjustable between 10 and 100 megohms at 350 VDC. For a bare-ended cable prior to installation of connectors, the Circuit Seek function automatically identifies both ends of a conductor for tagging or installation at the rate of about 0.03 seconds per wire. The 10,000 tests required for insulation resistance check of a 100 conductor cable can be performed in 200 seconds by one operator. The Cable Inspector consists of two portable units measuring 24″ x 6″ x 14″. Special fixtures are available for testing shaped harnesses. The photograph illustrates its use for identifying and tagging individual wires in a multiconductor cable. The insert shows a special fixture used in conjunction with the Inspector to test jet engine harnesses.

★ ★ ★

Reflex machines for Vickers, Knoop, Grodzinski, Brinell and Rockwell hardness tests are being introduced by **Gries Industries, Inc.,** Testing Machine Division, New Rochelle, N. Y. Loads from 1 to 250 kg may be selected by push button, since all weight blocks remain in the machine. Optical elements are manufactured by Carl Zeiss. After the test load has been removed, the greatly magnified image of the indentation produced is automatically projected on the ground glass screen. Magnification up to 140 times permits accurate measurement, and the ground glass may be replaced by a photographic plateholder.

★ ★ ★



Rimat Tool Co., 21 W. Dayton St., Pasadena 2, Calif., now makes available a new internal groove gage head for the checking of a wide range of "0" ring grooves, snap

How to speed production with MAGNIFIERS

New! Illuminated 10X Pocket Magnifier

WRITE for new handbook and catalog, "Industrial Magnifiers—How to Choose and Use Them." Bausch & Lomb Optical Company, 50233 Bausch St., Rochester 2, N. Y.

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ring grooves and short counterbores. Gage heads are available from stock and are interchangeable with all other standard Rimat gage heads on Rimat standard gage bodies. Groove diameters ranging from ¼" to 5" may be measured accurately to .0001" with this new series of gage heads. Each gage head has an exceptionally wide range of adjustment and can be quickly changed from one size to another.

★ ★ ★

Ardec, Inc., of Media, Pa., have taken over manufacturing and distribution rights in the United States and Canada for a Swedish developed line of adjustable plug gages. A total range of 0.708" to 2.835" is possible with six of the adjustable "go" and "not-go" gages. Ardec gages can be set with micrometer, indicator, or gage blocks, depending on accuracy required. After setting, the gage can be locked and wax-sealed to prevent tampering. Long jaws of the gage permit straight entering, and because of the design, an operator can determine whether or not a bore is "out of round."

★ ★ ★

New Literature

Typical applications, properties, chemical resistance and application of EC-1252 Tamper Proof Sealer are described in a data sheet available from the Adhesives and Coatings Division, **Minnesota Mining and Manufacturing Co.**, 423 Piquette Avenue, Detroit 2, Mich. The data sheet describes how critical or delicate parts or instruments can be safeguarded from unauthorized handling, since a break in the seal is readily detected and cannot be repaired.

From the Scrap Box

Contributions for the Scrap Box Department should be addressed to: Prof. Mason E. Wescott, Chairman, Editorial Board, University College, Rutgers University, New Brunswick, N. J.

QUALITY CONTROL AS A THREAT*

—Or Six Ways to Lose Friends and Aggravate People

Quality Control a threat? I can hear some indignant snorts at the very idea. Haven't we been reading and hearing for years now that modern statistical quality control brings with it all kinds of good things? Shops are not going to turn out scrap. Costs will go down. Inspectors will be friendly helpers to the machine operator. Buyers and sellers will end their haggling. Even engineers (so help us) are going to turn out practical designs!

A threat indeed! All right—you and I are smart enough to know that quality control is not a threat. But how about the human beings on the receiving end of our excellent ideas; the people who have to get into the act if we are to put our theories to practical use? If you will be patient for a little, I think I can show that there are at least six kinds of threat that they will feel when we approach them with our plans for improvement.

⁂

Let us suppose that you are ready to put inspection in receiving on a scientific sampling basis. You have determined Acceptable Quality Levels, balanced Consumer's and Producer's Risks, prepared a straightforward set of instructions. You are prepared to demonstrate to all and sundry that your plans will improve quality protection, reduce costs and do any number of other admirable things. Now you set out to indoctrinate Joe, the foreman of receiving inspection. Joe is no slouch. In fact he has the curiosity to ask how you know the plan guarantees a stated level of quality. Some of those acceptance numbers look pretty big. So you pull out your Operating Characteristic Curve—you are quite proud of it—and start explaining.

Right away you are in trouble. Joe's friendly curiosity cools off. You have gotten him in over his head. He feels uncomfortable and resentful. Threat number one is operating—the Threat of Dignity. Most of us are sensitive about "showing our ignorance" or admitting that we don't quite grasp a new concept. Statistical quality control unfortunately abounds in terms that scare people away because they are afraid that they will look foolish in trying to discuss them. The very word "statistical" is annoying because people stumble in pronouncing it.

⁂

You are probably ahead of me; you know better than to toss around big words and so you get past the first threat. Now you are explaining to Joe that the records of sample results will provide vendor rating. This can be used for further economics. If ten shipments from Ace Manufacturing show good results, a table of reduced sampling can be used; whereas, if King Corporation gets into trouble, a tightened inspection is applied.

For some reason Joe does not seem to see the logic or value of this procedure. He knows very well which are the good suppliers: Ace always sends in good material, whereas that King outfit is just no good—if purchasing would only listen to him. Why all this record keeping and charting? You know your arguments are better than

*Pamphlet reprinted here with the permission of Hughes Aircraft Company and sent to us by David A. Hill, Director of Quality Control at Hughes. Limited supply of the pamphlets are available on request to the author. G. R. T.

Joe's, but they seem to be making little impression. Why? Because the second threat is operating—the Threat to Freedom of Choice. Joe has precious little freedom these days in running his job. He cannot fire a lazy inspector without having the union on his neck. He has little to say about schedules and workloads. He cannot return material to a vendor without having purchasing, engineering, production control and heaven knows who all insisting on being in on the act. Up to now he was at least free to decide when to tighten down and when to ease up on checking material. Now your fancy new plan takes this away. Your statistics will provide the decision. Joe resents this threat to his freedom of choice even if he cannot put into words why it bothers him.

* * *

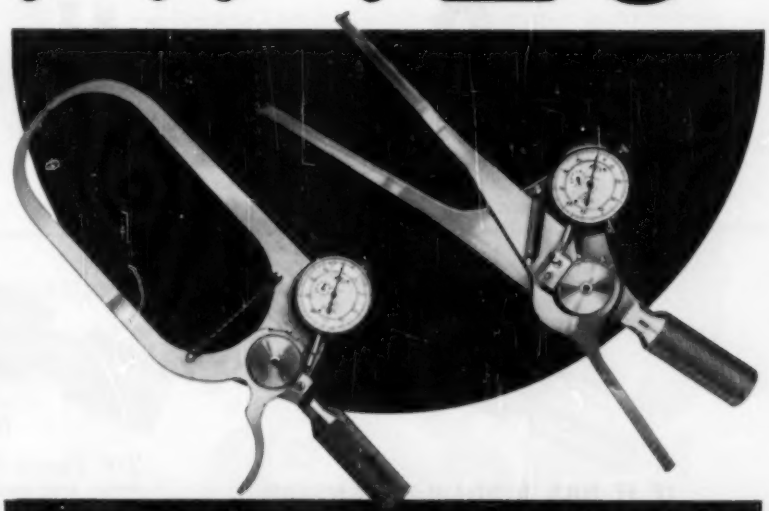
Let me switch the scene now to another area of the quality control engineer's activity. Through a lot of patient work the Machine Shop has been sold on the value of control charts. Several successful applications have been made. The shop has seen for itself that rework is cut. The road is clear ahead except for that pesky milling operation. There the points on the chart are forever skidding past one control limit or another. The superintendent has gone along with getting better cutters, improving the holding fixture, even overhauling the machine. It is no use. The six sigma spread of the operation just is not going to fit into the engineering tolerances, and the shop looks to you for your next move.

Your course is clear. Armed with reject percentages and frequency distributions you go after engineering to get relief. An experiment is needed to determine whether broader tolerances can be allowed. But the liaison engineer hedges on what he can allow. The project engineer appears certain that the shop could make the part if they were not such knuckleheads. The chief engineer is dubious about spending the money necessary to test the effect of a more liberal tolerance.

Why this dim view of your reasonable and well-supported proposition? You are seeing the effects of a third threat—the Threat to Group Prestige. Perhaps the design of that part solved a tough problem of specified performance. Perhaps engineering is all wrapped up in the

(Continued on page 42)

AMES



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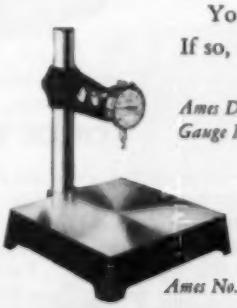

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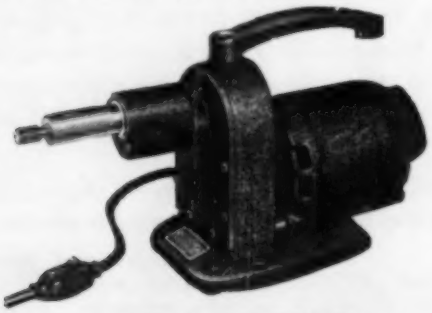

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T-P Precision Gage Blocks are the ultimate in accuracy. They provide a dependable master against which to check your production gages. Furnished in small or large sets capable of measuring increments down to 0.00005″. Carbide Wear Blocks are also available to increase the life of your set.

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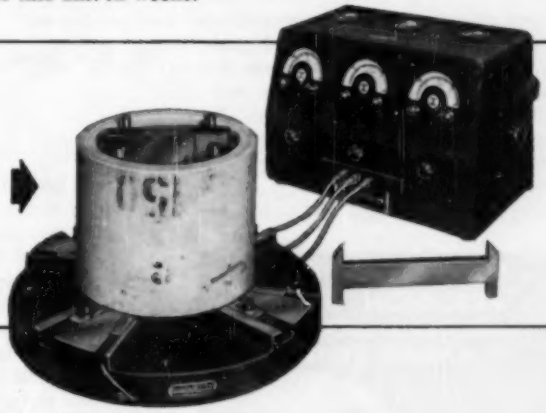
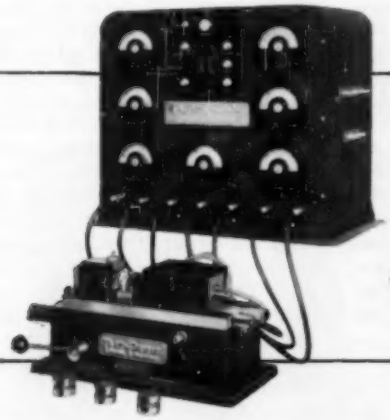
This T-P Multi-Dial CompAIRator checks several dimensions simultaneously where tolerances are .120″. Similar units for tolerances up to .125″ can be furnished with any number of indicators and gaging members.





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WOONSOCKET, R. I.

T P

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new model. But most of all you, my friend, are a rank outsider presuming to question the result of engineering's united efforts. The same thing can happen in a shop, with purchasing, with production control, with any group that the quality control engineer approaches from the outside. The customary cry is, "Don't tell us how to run our job."

A fourth threat lurks beneath the surface of many of quality control's improvements. Let us say that assembly inspection has been plodding along, weeding out the rejects at the end of the line. The foreman and his fifteen inspectors are generally hard pressed to keep up with schedules. Rework and reinspection are heavy. Now the quality control engineer moves in. Charts are put up to show everyone the level of quality. Defects are tabulated and the most frequent trouble makers subjected to methods improvement. An inspection operation is spotted at a critical point early in the line. The results begin to show and it is obvious that soon final inspection effort can be cut to about half of its previous level. Good work; congratulations; everybody is happy.

"How Do You Want This, John, on The High Side or Low Side?"

The above cartoon comes from Wade R. Weaver, Republic Steel Corp. *Ed.—No Comment.*

Everybody? How does all this appear to the inspection foreman? He had almost sold the boss on giving him three more inspectors. Bigger force under him: more chance of a raise. Now he is in danger of being cut down to eight or nine men. Is he going to give the quality engineer's projects his unqualified support? Number four, the Threat to Security, is at work. It appears in one form or another in most changes—not always as obvious as in the example above, but there just the same.

Who is going to get the credit for all these bright ideas, anyway? The foreman has an unhappy feeling that the quality engineer will eventually write up a handsome report, with charts to bring out clearly the contrast between the previous sorry conditions and the present efficient operation. Will this help the foreman in his efforts to climb to a better job? Fat chance! And so the quality engineer appears as a Threat to Personal Ambition—number five.

Finally, we in quality control are universally dedicated to change. We are the prophets of a new and better way. But people tend to find change uncomfortable. The floor inspector has to enjoy his varied and somewhat erratic round of visits to the machines. When a job gets into trouble, he was always on the other side of the shop checking a first-piece set up. Is he supposed to take to the idea of being at a specified machine at fixed intervals to take an exact number of measurements? The purchasing agent has developed pleasant relations with a list of suppliers. Does he want their shortcomings mimeographed for half the plant to see? The finishing foreman is sure he has a sixth sense for when to strengthen a plating solution and does not need to be running for a laboratory analysis all the time. We all have a long list of habits. Asking us to change them is like asking a man to come to work in kilts starting Monday morning. The Threat of Old Habits is number six.

The industrial psychologists tell us that when our proposals meet resistance and our sales talks do not go over there is a good chance that one of these six threats—more likely several of them—is working on the person we want to reach. The rigor of our mathematical proofs, the precision of our techniques, the brilliance of our advance planning all have very little effect on removing

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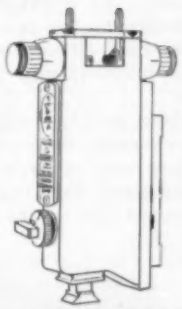
One machine is accurately checking 8 dimensions simultaneously—separating correct, oversize, and undersize parts at a rate of 2100 an hour.

Two girls now handle an inspection job that formerly took six—and human errors have been eliminated.

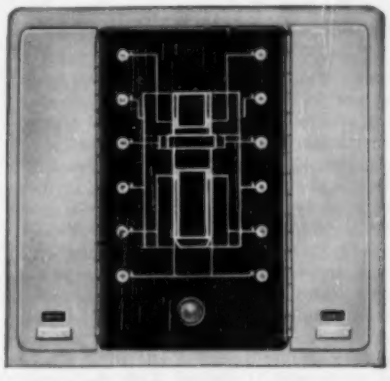
Eight, standard Sigma gauges, like this one: have been mounted together for rapid, accurate inspection of mass produced parts. Each gauge, accurate to within .00005", measures one dimension. More (up to 30) or fewer gauges could have been used, depending on the number of dimensions to be checked. These gauges, with standard Sigma mounting units, and special fixtures where necessary, can be set up to inspect parts a fraction of an inch long, or several inches long, a foot, or longer.



Depending on the arrangement, they can check internal and external diameters, length, depth, or other characteristics. The type of parts and the method of feeding determine inspection rates—hand feed: up to 600/hr.; semi-automatic: up to 900/hr.; fully automatic: up to 3500/hr. or more. Gauges are quickly and easily set to required tolerances and change-over from inspecting one type of part to another can be done within 10 or 20 minutes.

EASY-TO-READ INDICATORS WITH SIGMA EQUIPMENT

The semi-automatic Turbine and Compressor Blade Inspector (left) is an excellent example of Sigma's solution for a difficult inspection problem involving 18 dimensions. Fixtures are replaceable—each machine can inspect a wide range of different type parts. Gauges are connected to a Liquicolumn Indicator which has tubes of colored liquid set beside graduated scales—liquid levels indicate actual sizes of dimensions being checked. Magnifications can be varied easily by the user. Alternate indicator (right) uses electrical signals—green light for acceptable parts, red lights indicate dimensions below tolerances, yellow lights for those over. Built-in counters tabulate the number of parts submitted for inspection and the number accepted.



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them. Yet the probability of setting out to introduce quality control ideas without stirring up these threats in the minds of those we must work with is too small to find in the tables.

Fortunately the same industrial psychologists suggest a number of things that we can do to avoid appearing as a threat—or at least to reduce the aggravation. We have mentioned using plain talk and terms that are familiar to our listener. Perhaps, if we take the time, we can help the foreman or engineer to see that our proposal gives him a chance to expand his area of operation. He can use the tools we offer to handle new kinds of problems. Any effort we spend toward "getting on the team" will certainly be rewarded. We can listen to their headaches, help them remove the stumbling blocks in their path, share problems of working out practical applications. We might even learn a few things in the process! The man who takes off his coat to help with the house-raising is not an "outsider."

How about getting the man or the group personally involved? Avoid coming out with a perfected plan, all cut and dried. Find out first what improvements Joe thinks are needed. Can he help to gather facts to support the need for change? Does he have ideas to contribute to the forms, the instructions, the reports? We can make sure that his contributions get plenty of mention. Then we are partners. Joe has a stake in the outcome. His security and his ambitions are helped, not threatened.

Modern quality control has scored some notable successes. There have also been failures and places where it fell short of its high promise. I do not know how the data could be gathered to prove my case, but I have a strong feeling that there have been many more failures due to human problems than due to faulty mathematical statistics. I often hear quality control engineers complaining about how "they" resist or obstruct or run down the engineers' best efforts. When I hear this, I wonder whether the quality engineer took the trouble to find out whether he appeared to the other fellow as a threat. Did he include on his mental check list:

The Threat to Dignity
The Threat to Freedom of Choice
The Threat to Group Prestige
The Threat to Security
The Threat to Personal Ambition
The Threat to Old Habits

American Iron and Steel Institute Announces Formation of a Product Standards Committee for Analysis and Coordination of Statistical Studies in the Steel Industry

Much of the technical material used by the steel industry and by steel consumers is of a statistical nature. For the sake of uniformity in the collection of statistics and to assist in the analysis or interpretation of such statistics, the Board of Directors has set up a Committee on Product Standards to assist the General Technical Committee and the Product Technical Committees in the fine work which they are doing.

The new committee consists of twelve men. Four of them are statisticians versed in the latest methods of collecting and analyzing statistics of all types, particularly where machine methods are involved, and eight of them are technical statisticians well versed in the technology of steel as well as in the latest statistical techniques involving quality control. They will supplement and complement the work of the various technical committees, lend their assistance wherever it is deemed necessary or desirable, and generally see to it that all our technical statistical work is performed in accord with the most modern analytical methods. Members of the committee are:

Chairman:
Horace C. Stringfield, Asst. to Exec. V. P.-Accounting
United States Steel Corp.
Pittsburgh, Pa.

G. W. Abson, Staff Metallurgist
Jones & Laughlin Steel Corp.
Pittsburgh, Pa.

Douglas H. W. Allan
Process Division, Dept. of Metallurgy
Steel Company of Canada
Hamilton, Ontario, Canada

E. H. Howells, Asst. Metallurgical Engineer
Bethlehem Steel Co.
Bethlehem, Pa.

Kenneth Kramer
Youngstown Sheet & Tube Co.
Youngstown, Ohio

Frank Norris, Metallurgical Eng. (Statistics)
Wheeling Steel Corp.
Steubenville, Ohio

H. T. Oatman, Metallurgical Engineer
Allegheny Ludlum Steel Corp.
Brackenridge, Pa.

A. M. Reed
Bethlehem Steel Co.
Bethlehem, Pa.

E. L. Resler, Asst. Controller
Jones & Laughlin Steel Corp.
Pittsburgh, Pa.

John V. Sturtevant, Process Metallurgist
United States Steel Corp.
Pittsburgh, Pa.

Ralph E. Waldo, Asst. Comptroller
Republic Steel Corp.
Cleveland, Ohio

W. R. Weaver, Dir. of Steel Conservation and QC
Republic Steel Corp.
Cleveland, Ohio

The committee is specifically charged with the detailed preparation of scientifically designed plans for the collection of data for industry-wide surveys and the guidance of subsequent statistical analysis. Frank Norris is chairman of the Society's Metals Technical Committee.

(Continued from page 3)

We must express our deepest appreciation for the sincerity and zeal with which Dr. Deming applied himself to the mission our organization has been undertaking. Without his able exposition of the theory underlying statistical quality control, Japanese industry could never have benefited so widely and soon from the use of this valuable tool. At the present time there are, in Japan's industrial plants, several thousands of capable quality control engineers who, in hundreds of places, are applying their knowledge for improvement of quality, elimination of waste and other technological advances. They have succeeded so well in spreading the use of the technique that to deprive our manufacturers of SQC would be like taking away a blind man's cane.

The recipient of the 1952 Deming Prize was Keizo Nishimura, president, Furukawa Electric Company, Tokyo. The following is an excerpt from his acceptance address:

While deeply appreciating the high honor of our company's being the recipient of the Deming Prize, I, as head of the company, have great misgiving as to whether we deserve it, as the quality control operation at our works is but in its initial stage. We are firmly determined to carry it on more arduously and thoroughly in a manner worthy of the prize. Incipient as it is, the enforcement of quality control has given us a fairly handsome profit, amounting to an appreciable sum of money, to the no small surprise of myself and my people concerned. I now implicitly believe that, if quality control is taken up by all sections of Japanese industry, the benefits that they derive therefrom will be incalculably great.

I confess that it was not without skepticism that I first listened to Dr. Deming's assertion that quality control is the key to the reconstruction of Japanese industries, and that its adoption would make an epoch in Japan's industrial history; but now I know that it is every inch true. We must make redoubled endeavors for the spread of this theory and its practice in our industrial circles. When I presented an outline of the quality control operation in our company to the elders of the Japan Mining Engineers' Association the other day, they were interested in it so much so that, at their request, some 20 of them were invited to our Nikko Works to see how it is actually carried on there. Thus, we are doing our utmost to propagate quality control, whenever the opportunity offers. . . .

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Local Section News

"... BUT NOT FORGOTTEN

LINCOLN Dr. E. P. King, Eli Lilly & Co., spoke at the July 9 dinner meeting on the topic "Designing Experiments."

LOS ANGELES The executive committee of the Los Angeles section completed its program planning for the coming year. The theme will be the Purpose of Statistical Quality Control in Industry, starting with its fundamental role in industry and ending with its use in research. The program is designed to promote interest among the newcomers and to provide additional information to the regulars.

WESTERN MASSACHUSETTS The second executive committee meeting for 1954-55 season was held at Church Mfg. Co., Monson, Mass. The plan this year is to aim each of the technical meetings at a specific industry. It is expected that this plan will serve the members better since it will permit the discussion of specific problems and applications rather than generalities.

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"... CAST THEIR SHADOWS BEFORE"

BALTIMORE The season will ring open on Oct. 20 with a dinner, plant tour, and presentation of quality methods at the Radio Division of Bendix Aviation Corp., Towson, Md. The presentation will include Bendix's Vendor Quality Rating System.

KANSAS CITY The Kansas City section will have a panel discussion as the program for the October dinner meeting. R. W. Weeks, Westinghouse Electric, will be the moderator. A panel composed of representatives of assembly, testing and government inspection facilities will lead the discussion on "Assembly and Test Quality Control Problems."

MICHIGAN The first speaker of the 1954-55 season will be Prof. John A. Henry, University of Illinois. The meeting will be held at Wayne University in Detroit on Friday evening, Oct. 15. Prof. Henry's topic will be announced later.

MILWAUKEE The Milwaukee section will feature "Management Night" for its Sept. 20, 1954 meeting at the Wisconsin Hotel. The featured speaker will be J. F. Roberts, vice president and director of engineering, General Machining Division, Allis-Chalmers Corp. Mr. Roberts will talk on the subject "Value of Quality Control to Modern Industry."

NEW HAVEN The second regular monthly meeting of the 1954-55 season will feature J. W. Morrison, American Bosch Corp. as guest speaker. His subject will be "Using the Tools of QC." A dinner will be held prior to the business meeting and talk.

STATE UNIVERSITY OF IOWA The initial meeting for the coming year will be a two-day session at the Sheaffer Pen Co., Fort Madison, Iowa, on Sept. 24 and 25. An attractive array of speakers and a plant tour will be included in the program.

WESTERN MASSACHUSETTS The first meeting of the section has not been firmed, however, it will be in late September. The subject speaker, time and place will be announced by

mailed notices in ample time to allow members to make plans to attend.

YOUNGSTOWN Dorian Shainin will be our first speaker of this season and his subject will be "Chart Control Without Charts." It will be a dinner meeting at the V.F.W. on Oct. 14, 1954.

"AS YE SOW . . ."

ALBUQUERQUE The University of New Mexico in cooperation with the Albuquerque section will present a 12-week course in Statistical Quality Control starting Sept. 20. This will be an introductory course and will be offered in the University's Community Evening College. A. S. Hayes and J. M. Wiesen will conduct the course.

GEORGIA TECH An eight-day intensive advanced training course in statistical methods of quality control will be offered by the Georgia Institute of Technology Nov. 10-18, 1954.

Techniques applicable to all industries will be studied along with special problems of interest to the textile industry. This course is designed for those who have training equivalent to that afforded by one of the standard basic short courses in statistical quality control. Enrollment will be open to all who desire to learn more about the statistical approach to industrial problems.

Tuition for the course is $150 which includes all texts, supplies and a class banquet. Further information about the course can be obtained from: R. E. Eskew, Coordinator, Short Courses and Conferences, Georgia Institute of Technology, Atlanta, Ga.

NINTH MIDWEST QC CONFERENCE The Dallas-Fort Worth section is this year privileged to be your host at the Ninth Midwest Quality Control Conference. Inasmuch as this is the Society's first Texas conference, we naturally wish to uphold tradition by presenting for your approval, the very best in educational and technical sessions, accommodation facilities, and entertainment.

The theme of the Ninth Midwest Quality Control Conference is to *create, promote,* and *stimulate* the interest of industry in scientific applications of quality control, designed to *increase production, improve quality* and *lower cost.* The conference planning committee proposes to meet these objectives with a program, explicitly designed to meet your requirements. Foremost leaders in the field of quality control will conduct clinic sessions of such diversified interests that a member of *any* industry may, without exception, expect to profit from the knowledge these sessions will provide.

Headquarters for the conference will be the Baker Hotel at Dallas, providing one of the finest convention facilities in the Southwest. Our exhibitors promise to display the very latest in the tools of quality control. And for the ladies, an exceptional program, headed by a fashion show arranged by Neiman-Marcus, internationally known leader in fashion design.

The entire Midwest Conference is working hard to make the "Ninth" the caliber of conference you have become accustomed to expect. For registration information, write to 9th Midwest Quality Control Conference, Dallas-Fort Worth Section ASQC, Box 1262, Fort Worth 1, Texas. See you on Nov. 18, 1954.

MILWAUKEE The Third Industrial Clinic for Quality Control will be held on Oct. 20, 1954 at the Wisconsin Hotel, Milwaukee. This all day clinic will offer a choice of four technical sessions each period.

One series of three lectures is being devoted to SQC in the brewing and malting industry. Two series of three lectures each, will cover general SQC applications in industry. Such prominent speakers as Paul Robert, Dorian Shainin, Ervin Schiesel, Dale Lobsinger, James Barrabee, and Adam Abruzzi will present these lectures.

For the beginners or the forgetters, James R. Schaefer, University of Wisconsin, will present "Three Lessons in Quality Control," an educational series.

The Clinic will begin at 9:00 AM with the keynote presentation by John S. Randall, Division Manager, Automotive Group, A. O. Smith Corp. Dr. George Clark Kuebler, president of Ripon College, is to be the luncheon speaker. This is a full day of quality control at its best. For further information, write to Arnold E. Jakel, general chairman, Industrial Clinic for Quality Control, P.O. Box 1204, Milwaukee, Wisconsin.

EIGHTH NEW ENGLAND CONFERENCE The Eighth New England Conference will be held at the Ten Eyck Hotel, Albany, N.Y. on Oct. 21, 22, and 23, 1954.

A new feature of the conference will be a management seminar on quality control conducted by three industrial consultants in this field.

Clinic sessions, educational programs, and factory visits also have been arranged. These will be of interest to persons in allied fields as well as to quality control personnel.

The Northern Regional Meeting of the Textile Division of ASQC will be held in conjunction with the Eighth New England Conference.

For additional information write to Southern Connecticut Section, ASQC, Box 1681, Bridgeport 1, Conn.

NEW HAVEN This section will conduct basic and intermediate courses in Statistical Quality Control during the fall season, in eight weekly sessions from September through December, 1954.

QC METHODS IN ELECTRONICS A national symposium on quality control of electronic components, is scheduled to be held in New York on Friday and Saturday, Nov. 12 and 13 at the Hotel Statler. This symposium is being sponsored jointly by the Professional Group on Quality Control of the Institute of Radio Engineers and the Electronics Technical Committee of the American Society for Quality Control.

This two-day national symposium will have four sessions, featuring experts in the field of quality control from all branches of industry, research and government agencies.

The following is a brief resume of some of the main topics to be covered:

(1) Case histories of quality control applications in radio and television.

(2) The relationship of military electronic equipment to quality control.

(3) Clinic of current quality control application problems in the electronic industry.

(4) Tutorial theory and philosophy of quality control.

STATE UNIVERSITY OF IOWA For the third consecutive year the section will sponsor a ten-week training course in the Principals of Quality Control at Augustana College in Rock Island, Ill. The class will meet on Tuesday night of each week beginning Oct. 5. Competent instructors will be selected from the membership of the section.

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(Our organization also renders a consulting Service to Industry in instituting Statistical Methods of Quality Control.)

WESTERN MASSACHUSETTS Plans are being made with the University of Massachusetts Extension Division to organize a course in the Springfield area. The content will be on a college level with emphasis on advanced techniques.

"FOR MANY ARE CALLED, BUT FEW ARE . . ."

BUFFALO Officers for 1954-55 are: Chairman, Edward J. Delate, E. I. DuPont de Nemours Co.; Vice Chairman, Edwin L. Sexton, The Best Foods, Inc; Secretary, W. W. Irvine, Sigma Quality Control Group.

STATE UNIVERSITY OF IOWA Officers for the coming year are: President, Robert H. Wright, Deere and Company, Moline, Ill.; Vice president, H. R. Turney, Solar Aircraft, Des Moines, Iowa; Secretary-Treasurer, H. R. Harrison, Collins Radio, Cedar Rapids, Iowa.

WORCHESTER The 1954-55 officers are: Chairman, Arthur Pingalore, Telechron Co.; Vice chairman, Warren Arnold, Draper Corp.; Secretary, P. Roy Leaman, Bay State Abrasive Products Co.; Treasurer, Charles Reed, Telechron Co.

YOUNGSTOWN New officers for the coming year are: Chairman, W. A. Griffith, Packard Electric Div., GMC; Vice Chairman, D. J. Ausmus, Timken Roller Bearing Co.; Secretary, F. J. Jayne, Trumbull Lamp Works; Treasurer, V. P. Ahier, Truscon Steel Co.

SIGNIFICANT DIFFERENCES

The first honorary professorship in statistical quality control awarded by Rutgers University was recently given to Dr. Walter A. Shewhart, pioneer in statistical quality control techniques and research engineer for the Bell Telephone Laboratories, by Dr. Lewis Webster Jones, president of the university.

Three Important New Wiley Books on Statistics . . .

The Foundations of Statistics

By LEONARD J. SAVAGE,
University of Chicago

In this important new work the author concentrates on the human, or personal, aspect of statistical probability. He believes that the purely personal factor is vital in decision and in a cogent defense of this viewpoint he offers a theory of decision-making under uncertainty in which both statistics and probability are imbedded in a general system of rational behavior. He treats an area in which there is much controversy, and contributes to several ever-open issues such as the principle of insufficient reason and the application of the Bayes' theorem. A unique feature of the book is its emphasis on the role of economic behavior in statistics.

1954 294 pages $6.00

INTRODUCTION TO Mathematical Statistics

New Revised 2nd Edition

By PAUL G. HOEL,
University of California, Los Angeles

Reorganized and expanded, the second edition of this comprehensive introductory book places greater emphasis on theory. An entirely new chapter on probability provides the elemental basis necessary for the development of statistical theory. Statistical inference is thoroughly treated. The chapters on correlation and regression are thoroughly rewritten with greater emphasis on regression. There is added material on nonparametric methods and analysis of variance.

1954 331 pages Illus. $5.00

Statistical Analysis IN CHEMISTRY AND THE CHEMICAL INDUSTRY

By CARL A. BENNETT,
General Electric Company, and
NORMAN L. FRANKLIN,
University of Leeds, England

Sponsored by the Committee on Applied Mathematical Statistics, National Research Council, National Academy of Sciences, Washington, D. C.

Here is a development of those aspects of applied mathematical statistics which will be continually useful to chemists and chemical engineers. It starts from the beginning of the subject and, dealing with each topic as completely as possible, gives the theoretical background and derivation of the methods, together with computational procedures. Selection of the methods and their development goes beyond that of any previous book on the subject written for chemists and presents more examples from the chemical field than any other work. Many recent developments in the field of applied mathematical statistics have been included, together with illustrative examples of their applications in chemistry.

1954 724 pages Illus. $8.00

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Dr. Shewhart is one of eight scientists, who have received honorary professorships from Rutgers University, but the only one to have received such an appointment in the field of statistical quality control.

His career began as an instructor in physics at the La Crosse, Wisconsin, Normal School. In 1918, he joined the Western Electric Company's Research Department, and in 1924 his present concern. He was engaged by the War Department from 1933-1944 to serve as a consultant on ammunition specifications and during the past six years he has helped to found and guide the Rutgers undergraduate programs in applied statistics.

Dr. Shewhart's service to ASQC is well known, but in addition he is a past president and fellow of the American Statistical Association and the Institute of Mathematical Statistics; a fellow of the Econometric Society, Royal Statistical Society, and New York Academy of Sciences; and a member of the American Physical Society, Mathematical Association of America, and the Acoustical Society of America.

* * *

Los Angeles Section reports that its treasurer, Kenneth Kilbourne, has recently been appointed chief of quality control at Standard Coil Products Co.—also that John Armeling is now with Steffer Motors Corp.

* * *

To keep on top of its affairs, the New Haven executive committee is holding monthly meetings at the committee members' homes prior to the regular monthly meetings. These informal meetings are proving to be highly successful. Refreshments served during and after the meeting are, needless to say, a popular feature.

ANNUAL REPORT of the BOARD OF DIRECTORS

American Society for Quality Control, Inc.

The Board of Directors of the American Society for Quality Control, Inc., presents herewith its Annual Report covering the fiscal year, July 1, 1953-June 30, 1954. This report is intended as a brief summary of Society activities, since the reports attached hereto are the detailed reports of the officers and committee chairmen. Further, the work of the Operating Committee, Executive Committee, and the Board of Directors has been reported from time to time through the columns of *Industrial Quality Control*.

ANNUAL MEETING

The Annual Meeting of the American Society for Quality Control, Inc., was held at 4 p.m., on Wednesday, June 9, in Kiel Auditorium, St. Louis, Mo. Annual reports of the officers were presented, as required by the Constitution, and were accepted with the condition that they be extended to cover the balance of the fiscal year.

The Committee of Tellers was appointed and carried out their duties as prescribed by the Constitution. Their report is appended hereto and is a part of this report.

BOARD OF DIRECTORS

Three meetings of the Board of Directors were held during the year. The first meeting was held May 29, 1953, in Philadelphia, Pa., for the purpose of electing executive directors. Following the election, the Board approved a schedule of meetings for the year which included a midyear meeting of the Board. An organization chart of Society activities and responsibilities was presented and approved as of July 1. The proposed budget was presented for the information of the Board.

The midyear meeting was held in Providence, R. I., November 7, 1953, with 21 of the 26 Board members present. Following brief reports from each officer, there was ample time for thorough discussion of several major Society problems. Action was taken on the following: (1) The report of the Section Representation Committee, concerning redistricting, was approved; (2) The Board recommended to the Executive Committee that the program of the Financial Advisory Committee be continued with the provision that certain additional controls be exercised by the Executive Committee.

The third meeting of the Board was held June 11, 1954, in connection with the Eighth Annual Convention, for the purpose of concluding its business for the year.

MEMBERSHIP AND FINANCES

Attached hereto are the reports of the Executive Secretary and the Treasurer. The Board recommends that each member give these reports their careful attention. It will be noted, however, that once again we can report a substantial gain in membership and the addition of several new sections. The Treasurer has maintained careful surveillance of our finances so that we have operated on a balanced budget and have made significant additions to our financial resources.

PUBLICATIONS

The report of the Editorial Board is attached hereto and summarizes the important phases of this Society activity. The Board notes with satisfaction the continued growth of our publications, and the efforts which are being made to increase their effectiveness to our membership.

AWARDS

One of the significant developments of the year was the initiation of the Presidential Award for Section Management. The award, created to honor the section which had done

the outstanding job during the year, has done much to stimulate sections to do a better job of managing their affairs, including membership growth and program planning. The award was presented to the Los Angeles section at the Annual Banquet of the Society.

The Shewhart Medal Committee and the Brumbaugh Award Committee were active during the year and their respective citations and awards were presented at the Society's Annual Banquet. Dr. Edwin G. Olds, author of the article, "The Place of SQC in an Industrial Organization," was the recipient of the 1953 Brumbaugh Award. The Shewhart Medalist for 1953 was Mr. Harry G. Romig. The citation and the address of the medalist were published in the July 1954 issue of *Industrial Quality Control*.

ACKNOWLEDGEMENTS

The Board of Directors acknowledges the importance of the work of local sections. The strength of the Society in the past and in the future rests at this point. The Board congratulates all sections for the fine program which they have conducted during the year and their willingness to cooperate with the Society on so many different occasions.

The St. Louis section and its Convention Committee are deserving of a special word of commendation for their efforts on behalf of the Society in conducting the Eighth Annual Convention. The Board hereby acknowledges with gratitude, and congratulates the Committee for a job well done.

The Board acknowledges with thanks the hospitality and arrangements provided by the Michigan Forum, the New England Conference, the Rochester Clinic, and the Eighth Annual Convention, for meetings of the Board and Executive Committee during the year.

Rochester, New York
June 30, 1954

For the Board of Directors
ALFRED L. DAVIS,
President

Appendix A: Report of the Executive Secretary

During the 1953-54 fiscal year, our membership reached the highest point in our history, 8548. This is the first time we have ever exceeded 8000 members. Also, the rate of renewals is slightly higher this year as compared to last year (77.4 percent as opposed to 75.0 percent). The highest renewal rate we have had is 81 percent for the 1951-52 year.

On the other hand, however, we received 2798 new members, which does not quite equal the total of 2846 new members obtained in the 1952-53 year.

Our net gain in membership for this fiscal year is 1118. This compares with a net gain of 1321 for the 1952-53 year and 1864 for 1951-52. Record of membership growth is shown in Exhibit "A." The breakdown as of June 30, 1954 is as follows:

	New Members	*Renewing*	*Total*
Fellows	0	156	156
Senior Members	138	1,758	1,896
Members	2,628	3,831	6,459
Members-in-Training	32	5	37
	2,798	5,750	8,548

The complete membership breakdown by sections is shown in Exhibit "B."

During the 1953-54 fiscal year there were 245 transfers from one section to another. Many of these transfers occurred because new sections were organized and members transferred from their present sections to the new ones. However, there seems to be a large number of transfers caused by members moving to different areas of the country.

New sections recognized during this year in order of their recognition are as follows:

	Section No.
Harrisburg	72
Baton Rouge-New Orleans	73
Burlington (Vermont)	74
Scranton-Wilkes Barre	75
Albuquerque (New Mexico)	76
Portland (Oregon)	77
Danville-Sunbury (Pa.)	78
San Bernardino (Calif.)	79
Winnebago (Wis.)	80

The New Haven, Youngstown, and Carolinas sections were recognized during the 1952-53 year, but first enrolled members as of July 1, 1953.

The Executive Secretary has received a number of complaints regarding the length of time it takes for a new member to receive *Industrial Quality Control* after he has paid his dues. This is the procedure through which a new membership must go before the first issue is received.

1. Dues to the section.
2. Dues included on Remittance Report sent by the Section Treasurer to the Executive Secretary.
3. Membership processed by the Executive Secretary.
4. Name of member sent to publications office in Milwaukee.
5. Name of member sent by publications office to printer.
6. Printer places name on mailing list and sends out back issues.
7. The Post Office delivers the magazines.

A short delay at each point can add up to quite a period of time. During the year changes have been made to minimize such delays. The entire system is now being intensively studied to see whether some of the steps can be eliminated.

In sending out bills for renewal dues for the 1953/1954 year, for the first time we included membership cards along with the bills in order to eliminate the delay between the time the member pays his dues and the time he receives his card. This also eliminated the work of sending cards individually, when the dues were received. The sections will continue to have a supply of membership cards to issue to new members, so that delay will be reduced to a minimum.

Membership certificates are available for $3.00 to members in good standing. Our agreement with the engraver of these certificates provided that because of this favorable price, we will submit orders in groups of ten or more. Therefore, during the past year, there was sometimes quite a delay between the time we received an order for a certificate and the time it was forwarded to the engraver. New arrangements have now been made with the engraver.

During the past year, Charters were issued to all existing sections and are being given to new sections as they are recognized.

The office of the Executive Secretary continues to act as an employment clearing house between members of the Society and industry. Because of the general economic situation, for the past several weeks we have received considerably more requests from members to be placed than jobs. Many of the sections have a placement committee, and the problem of how to coordinate section placement efforts with those of the Executive Secretary's office is being studied.

A professional job evaluation study of the work of the New York office manager and his two aides was made. During the year one stenographer resigned, her replacement was not kept on long, and a second replacement girl is now being trained.

The Executive Secretary acknowledges with appreciation, the many details of his work carried out so well by the New York Office Manager, Julian S. Herz.

DORIAN SHAININ
Executive Secretary

Exhibit A—Record of Membership Growth

Date	Members	% Renewal	Net Gain	% Gain	New Members	Active Sections	Members Rec'd for Following Fiscal Year
June 30, 1947	1926				1926	25	*
June 30, 1948	2102	*	176	9	*	31	*
June 30, 1949	2638	75.2	536	25	1058	35	*
June 30, 1950	3510	76.7	872	33	1489	42	58
June 30, 1951	4245	80.5	735	21	1422	48†	167
June 30, 1952	6109	81.2	1864	44	2669	60	207
June 30, 1953	7430	75.0	1321	22	2846	71	146
June 30, 1954	8548	77.4	1118	15	2798	80	254

*No Record. †One Provisionally Accepted

Exhibit B—Membership Report 1953-54

	Membership June 30, 1953		Membership June 30, 1954		
New England	Total	Fellows	Sr. Members	Members	Total
Albany	81	3	21	103	127
Boston	145	3	41	102	146
Buzzards Bay	52		3	49	52
Burlington			2	40	42
Hartford	191	2	28	120	150
N. Hampshire	20		6	13	19
New Haven		1	13	69	83
Rhode Island	49	1	13	43	57
So. Conn.	129	1	25	100	126
W. Mass.	85	4	23	56	83
Worcester	49	1	10	46	57
Total	801	16	185	741	942
Middle Atlantic					
Allentown-B.	72		10	47	57
Baltimore	91	4	12	99	115
Carolinas			8	66	74
Delaware	51	3	9	38	50
Harrisburg			5	85	90
Lansdale	93	1	10	62	73
Metropolitan	558	24	168	424	616
Philadelphia	293	5	80	195	280
Richmond	53		11	51	62
Trenton	61		10	29	39
Washington	75	5	21	72	98
Total	1347	42	344	1168	1554
Northern					
Buffalo	83		18	61	79
Mid-Hudson	64		15	100	115
Montreal	89	2	10	68	80
Rochester	102	8	72	50	130
Scranton-Wilkes Barre			5	41	46
So. Tier	97	1	21	90	112
Syracuse	149	3	20	129	152
Toronto	84	1	11	80	92
Utica	56		9	24	33
W. Ontario	52		16	56	72
Total	776	15	197	699	911
Central					
Birmingham	45		4	35	39
Cincinnati	82	1	11	122	134
Cleveland	332	7	104	243	354
Columbus	61	1	14	87	102
Dayton	136	4	16	87	107
Erie	35		3	43	46
Georgia	72	1	16	48	65
Grand Rapids	45	1	4	65	70
Gr. Muskegon	23		10	21	31
Huntsville	10		3	8	11
Louisville	63		9	59	68
Michigan	300	6	59	347	412
Parkersburg	38		13	20	33
Pittsburgh	84	4	28	96	128
Tennessee	72	1	21	66	88
Toledo	101	2	12	80	94
Youngstown		1	7	28	36
Total	1499	29	334	1455	1818
Midwest					
Baton Rouge-New Orleans				31	31
Central Illinois	35	2	21	16	39
Chicago	499	12	123	431	566
Dallas-Ft. Worth	130		31	80	111
Denver	45	1	6	42	49
Evansville-Owensboro	30		5	24	29
Indianapolis	290	4	52	226	282
Iowa	221	9	83	168	260
Kansas City	43		9	49	58
Lincoln	40	1	10	37	48
Milwaukee	246	2	63	140	205
Minnesota	83	1	25	80	106
Muncie	90	1	8	122	131
N. E. Indiana	66	2	14	52	68
Racine	53		19	32	51
Rock River Valley	46	2	15	31	48
St. Louis	121	6	35	88	129
South Texas	55	1	6	54	61
Wichita	128		18	70	88
Total	2221	44	543	1773	2360
Western					
Albuquerque		1	9	39	49
Japan	51		19	52	71
Los Angeles	173	4	91	169	264
Mexico City	26		8	23	31
Portland				33	33
Salt Lake City	27			28	28
San Diego	156		93	37	130
San Francisco	76	2	31	57	90
Seattle	59		3	65	68
Total	568	7	254	503	764
Members-at-large	187	3	39	120	162
Members-in-training	31				37
GRAND TOTALS	7430	156	1896	6459	8548

Appendix B—Report of the Treasurer

The Statement of Cash Receipts and Disbursements for the year ended June 30, 1954, the Income and Expenses versus Budget for 1953-54, the Balance Sheet as of June 30, 1954 and the Marketable Securities as of June 30, 1954 are presented here as Exhibits C, D, E and F.

This year budget figures for the quarters were based on a percentage of the total which was determined by taking the percentage of total over the past two years and applying to this year's budget. Since our income is generally much greater in the first and second quarters than in the last two quarters and some of our expenses are greater the last half year than the first, this method permitted more realistic comparisons of figures with the budget and aided in producing better control of the financial operations. However, our growth has continued and our income from dues was more than $3,000.00 greater than expected, in a year when some pessimism has existed. Our income from Advertising was off about $1,400.00 and our total income from Publications was below budget by $1,700.00.

On the expense side, our magazine printing exceeded the budget by about $1,500.00 but the total Publication Office Expense was within the budget.

All the other controllable expenses seem to be well within the budget except those of the Treasurer and Committees. The increase in the insurance item was brought about by the decision to increase the fidelity bond for certain officers. A reduction of 50 percent in one year was obtained by purchasing a three year bond. The figure of $835.38 includes the cost of this bond, as well as workman's compensation insurance for our employees and liability insurance at our offices.

The increasing load in the Treasurer's Office necessitated the purchase of an adding machine and the hiring of part-time help. Proper appropriations to cover these expenditures were obtained from the Executive Committee. The "other" Committee Expense exceeded the budget by approximately $500.00. However, this figure was well within the Supplementary Appropriation made by the Executive Committee to foster and encourage more committee activity.

LEON BASS

Treasurer

Exhibit C—Statement of Cash Receipts and Disbursements, Year Ended June 30, 1954

CURRENT FUNDS

Receipts			
Membership dues:			
Members in training		$ 80.00	
Regular members		35,668.00	
Senior members		14,758.00	
Fellows		1,826.00	
		$52,332.00	
Less refunds		38.50	$52,293.50
Publications:			
Advertising	$18,989.23		
Library subscriptions	2,873.33		
Sales of back issues	1,125.00		
Sales of reprints	780.21	$23,767.77	
Less cost of reprints and back issues		1,629.42	22,138.35
Sales of conference papers and other technical literature			1,451.75
Sales of membership certificates		$ 114.00	
Less cost of membership certificates		67.92	46.08
Sales of pins and insignia		$ 987.90	
Less cost of pins and insignia		556.61	431.29
Interest received on bank deposits			614.87
Annual Society convention:			
1954 convention income		$ 8,269.64	
Refund from 1954 Committee		1,100.00	9,369.64
Rental of Society films			55.00
Bibliography fund			350.00
Division dues not transferred as of year-end			9.50
Income and social security taxes withheld from employees		$ 3,281.03	
Less payments to Director of Internal Revenue		3,177.52	103.51
Miscellaneous income			869.67
TOTAL RECEIPTS			$87,733.16
Disbursements			
Publications:			
Cost of authors' reprints	$ 908.93		
Less cash received from authors	313.75	$ 595.18	
Publishing:			
Magazine	$24,550.69		
News supplement	2,030.45		
Index	261.85	26,842.99	
Postage and mailing expense:			
Magazine	$ 1,572.58		
Back issues	562.40		
News supplement	1,001.27		
General	227.38	3,363.63	
Salaries		9,210.55	
Advertising commissions and cash discounts allowed		2,287.61	
Office supplies and expense		2,048.39	
Rent		948.39	
Traveling expenses		722.63	
Printing and mimeographing		70.56	
Sundry		323.97	$46,413.90
Committee and sections:			
Traveling expense:			
Executive		$ 232.12	
Other		232.29	
Printing, mimeographing, and postage		799.46	
Executive Committee meetings and sundry expense		379.30	1,643.17
President and Vice President:			
Secretarial services		$ 1,265.00	
Traveling expenses		887.48	
Office supplies and sundry expense		239.88	2,392.36
Executive Secretary:			
Secretarial salaries		$10,920.99	
Printing and mimeographing		3,298.38	
Postage		568.97	
Office supplies and expense	$ 1,257.02		
Less reimbursement by sections	248.27	1,008.75	
Office rent		1,551.76	
Traveling expense		556.66	
Public relations material and technical literature		356.76	
Office furniture and equipment purchased		552.78	
Sundry		7.35	18,822.40
Treasurer:			
Secretarial services		$ 560.00	
Insurance		835.38	
Professional services		357.26	
Office equipment purchased		288.00	
Sundry		13.97	2,054.61
Divisions:			
Publishing technical supplement		$1,623.50	
Postage and mailing expense—technical supplement		37.34	1,660.84
General:			
Pay roll taxes expense		$ 313.39	
Transfer to Investment Income Fund		14,188.70	
Advance to 1955 Convention Committee		1,000.00	
Advance to Technical Committees		500.00	
Residual committee expense	$ 924.20		
Less residual committee income	753.03	178.17	
		$16,180.26	
Less decrease in amounts of imprest petty cash funds		156.78	16,023.48
TOTAL DISBURSEMENTS			$89,010.76
CASH DISBURSEMENTS IN EXCESS OF CASH RECEIPTS			$ 1,277.60
Cash on hand and on deposit at June 30, 1953			36,967.17
Cash on hand and on deposit at June 30, 1954			$35,689.57

SPECIAL FUNDS

Textile Division Fund:			
Receipts:			
Membership dues		$ 244.00	
Conference income	$ 2,208.02		
Less conference expense	1,189.37	1,018.65	$ 1,262.65
Disbursements:			
Printing and mimeographing		$ 338.55	
Technical literature		359.36	
Postage		96.64	
Secretarial services		87.50	
Sundry		29.88	911.93
CASH RECEIPTS IN EXCESS OF CASH DISBURSEMENTS			$ 350.72
Cash on deposit at June 30, 1953			30.90
Cash on deposit at June 30, 1954			$ 381.62
Chemical Division Fund:			
Receipts:			
Membership dues		$ 299.50	
Conference income		43.35	$ 342.85
Disbursements:			
Printing and mimeographing		$ 71.85	
Postage		26.85	
Sundry		.39	99.09
CASH RECEIPTS IN EXCESS OF CASH DISBURSEMENTS			$ 243.76
Cash on deposit at June 30, 1953			60.98
Cash on deposit at June 30, 1954			$ 304.74
Shewhart Medal Fund:			
Receipts:			
Contributions by various sections		$ 162.50	
Interest received on bank deposit		19.95	$ 182.45
Disbursement:			
Cost of engraving medal			2.28
CASH RECEIPTS IN EXCESS OF CASH DISBURSEMENTS			$ 180.17
Cash on deposit at June 30, 1953			755.19
Cash on deposit at June 30, 1954			$ 935.36
Brumbaugh Award Fund:			
Receipts:			
Contributions by various sections		$ 237.50	
Interest received on bank deposit		47.53	$ 285.03
Disbursement:			
Cash award to Edwin G. Olds			50.00
CASH RECEIPTS IN EXCESS OF CASH DISBURSEMENTS			$ 235.03
Cash on deposit at June 30, 1953			1,815.20
Cash on deposit at June 30, 1954			$ 2,050.23
Presidential Award Fund:			
Receipts:			
Contributions by various sections		$ 200.00	
Interest received on bank deposit		2.38	$ 202.38
Disbursement:			
Engraving plaque			109.61
Cash on deposit at June 30, 1954			$ 92.77

Exhibit D—Income and Expense Versus Budget 1953-54

	Budget	Actual
INCOME		
Dues—In Training	$ 90.00	$ 80.00
Regular	31,976.00	35,668.00
Senior	15,395.00	14,758.00
Fellow	1,696.00	1,826.00
		$52,332.00
Less Refunds		38.50
Total Dues	$49,157.00	$52,293.50
Publications		
Advertising	$20,400.00	$18,989.23
Inst. Subscriptions	3,600.00	2,873.33
Sale of Back Issues	1,700.00	1,125.00
Sale of Reprints & Tech. Literature	1,200.00	2,231.96
Total Publications	$26,900.00	$25,219.52
Miscellaneous		
Pins, Cuts, etc.	$ 200.00	$ 431.29
Interest earned	750.00	614.87
Other Income	300.00	924.67
Total Miscellaneous	$ 1,250.00	$ 1,970.83
Total Income	$77,307.00	$79,483.85
EXPENSES		
Publications		
Printing—Magazine & Reprints	$24,800.00	$26,180.11
—Supplement	2,180.00	2,030.45
—Index	290.00	261.85
—General Publications	1,500.00	-
Mailing —Magazines	1,700.00	1,572.58
—Back Issues	300.00	562.40
—Supplement	1,040.00	1,001.27
Advertising Commissions	2,200.00	2,287.61
Salaries	9,610.00	9,210.55
Travel	500.00	396.19
Office Expense	700.00	697.71
Rent	882.00	948.39
Adv. Publicity	500.00	-
Delinquent Member Follow-up	-	153.96
Net Cost of Authors Reprints	300.00	595.18
Miscellaneous Advertising Expense	-	111.20
Editorial Office		
Travel	500.00	466.16
Office Expense	1,960.00	1,655.24
Total Publications	$48,962.00	$48,130.85

	Budget	Actual
Divisions		
Printing—Tech. Supplement	$ 3,000.00	$ 1,623.50
Mailing—Tech. Supplement	500.00	37.34
Total Divisions	$ 3,500.00	$ 1,660.84
Committees & Sections		
Executive Committee	$ 1,000.00	$ 611.42
Other Committees	500.00	1,031.75
Total Committees	$ 1,500.00	$ 1,643.17
President's Office		
Supplies & Expense	$ 150.00	$ 127.40
Salaries	1,300.00	1,265.00
Travel	1,000.00	847.90
Sundry	-	20.00
Total President's Office	$ 2,450.00	$ 2,260.30
Vice-President's Office		
Supplies & Expenses	$ 235.00	$ 45.32
Travel	-	40.39
Sundry	-	25.00
Total Vice-President's Office	$ 235.00	$ 110.71
Secretary's Office		
Printing & Mimeo.	$ 1,900.00	$ 3,298.38
Postage	1,000.00	$ 568.97
Office Supplies & Expenses	1,400.00	1,008.75
Salaries	11,700.00	10,920.99
Rent	1,500.00	1,551.76
Travel	600.00	556.66
Equipment	700.00	552.78
Tech. Literature & Pub. Rel. Material	-	356.76
Sundry	-	7.35
Total Secretary's Office	$18,800.00	$18,822.40
Treasurer's Office		
Supplies & Expense	$ 65.00	$ 13.77
Insurance	50.00	835.38
Audit Fees	325.00	357.26
Payroll Taxes	350.00	313.39
Salaries	-	560.00
Office Equipment	-	288.00
Total Treasurer's Office	$ 790.00	$ 2,367.80
Total Expense	$76,237.00	$74,996.07
Cash Income in excess of Expense for normally budgeted items		$ 4,487.78

Exhibit E—Balance Sheet as of June 30, 1954

ASSETS

Cash:				
Current funds:				
On hand for deposit		$11,064.75		
Demand deposit		2,617.26		
Time deposits—general		15,583.09		
Time deposit—convention reserve fund		6,424.47	$35,689.57	
Petty cash funds			94.47	
Special funds:				
Demand deposits:				
Textile Division Fund	$ 381.62			
Chemical Division Fund	304.74			
Investment Income Fund	2,606.62	$ 3,292.98		
Time deposits:				
Shewhart Medal Fund	$ 935.36			
Brumbaugh Award Fund	2,050.23			
Presidential Award Fund	92.77	3,078.36	6,371.34	$ 42,155.38
Marketable securities (at cost):				
United States Treasury bonds (market value $22,857.70)			$21,966.88	
Other marketable securities (market value $39,257.50)			37,419.53	
			$59,386.41	
Less reserve for possible loss from sale of securities			3,000.00	56,386.41
Accounts receivable:				
Interfund			$ 9.50	
From sales of advertising, magazine reprints, conference papers, technical literature, etc.			1,366.58	
Advance to 1955 Convention Committee			1,000.00	
Advance to Technical Committees			500.00	2,876.08

Exhibit E—Balance Sheet as of June 30, 1954

ASSETS (Cont.)

Inventories—at nominal amounts:		
Back issues of Industrial Quality Control conference papers and other technical literature	$ 1.00	
Stationery and supplies	1.00	2.00
Office furniture and equipment—at nominal amount		1.00
		$101,420.87

LIABILITIES, RESERVES, AND SURPLUS

Account payable—interfund		$ 9.50
Accounts payable—other		4,265.11
Salaries and wages		692.31
Taxes withheld from employees		923.63
Deferred income:		
Membership dues paid in advance	$ 1,592.00	
Estimated unearned portion of library subscriptions	957.00	2,549.00
Reserves:		
For Shewhart Medal Fund	$ 935.36	
For Brumbaugh Award Fund	2,050.23	
For Presidential Award Fund	92.77	3,078.36
Surplus		89,902.96
		$101,420.87

Exhibit F—Marketable Securities as of June 30, 1954

Description	Rate	Maturity	Principal Amount	Cost	Market Value	Income Received During the Year
United States Bonds:						
U. S. Treasury bonds	2⅜%	1959	$5,000.00	$ 4,973.75	$ 5,112.00	$ 118.75
U. S. Treasury bonds	2½%	1969	3,000.00	2,910.31	3,003.00	75.00
U. S. Treasury bonds	2½%	1958	5,000.00	4,978.44	5,155.50	125.00
U. S. Treasury bonds	2⅞%	1960	4,000.00	4,083.75	4,047.20	115.00
U. S. Treasury bonds	3¼%	1983	5,000.00	5,020.63	5,540.00	182.59
				$21,966.88	$22,857.70	$ 616.34
Other Bonds:						
Aluminum Company of America	3⅛%	2-1-64	2,000.00	$ 1,997.85	$ 2,055.00	$ 62.50
American Telephone and Telegraph Company	2¾%	12-15-61	1,000.00	1,075.80	1,225.00	27.50
American Telephone and Telegraph Company	3¾%	12-10-65	100.00	100.00	130.00	1.88
American Tobacco Company	3%	4-15-62	2,000.00	1,963.50	2,002.50	60.00
Bethlehem Steel Corporation	2¾%	7-15-70	1,000.00	915.80	993.75	27.50
Cincinnati Gas & Electric Co.	2¾%	10-1-75	2,000.00	1,839.10	1,977.50	55.00
Cleveland Electric Illuminating Company	3%	7-1-70	2,000.00	2,017.85	2,045.00	45.00
Consolidated Edison Company of New York	3%	11-1-72	1,000.00	963.30	1,023.75	30.00
Dow Chemical Company	3%	7-1-82	2,000.00	2,100.40	2,127.50	60.00
Firestone Tire & Rubber Company	3%	5-1-61	1,000.00	1,006.45	1,030.00	60.00
Pacific Gas & Electric Company	3½%	6-1-66	2,000.00	2,057.85	2,060.00	70.00
Pennsylvania Railroad Company	4¼%	4-1-81	4,000.00	3,819.50	3,745.00	85.00
Standard Oil Company of New Jersey	2¾%	7-15-74	2,000.00	1,811.00	1,990.00	55.00
				$21,668.40	$22,405.00	$ 639.38
Preferred Stocks:	**Shares**		**Par Value**			
Consolidated Edison Co. of New York, cumulative	10	$5.00	None	$ 1,094.10	$ 1,091.25	$ 50.00
E. I. duPont de Nemours and Co., convertible	15	3½%	None	1,392.15	1,481.25	52.52
Southern California Edison Company, convertible	40	4.48%	25.00	1,154.91	1,485.00	44.80
Sylvania Electric Products, convertible	10	4.40%	None	1,071.60	1,125.00	44.00
Virginia Railway Company, cumulative	40	6%	25.00	1,159.76	1,065.00	60.00
				$ 5,872.52	$ 6,247.50	$ 251.32
Common Stocks:						
American Telephone and Telegraph Company	10		100.00	$ 1,562.94	$ 1,668.75	$ 90.00
Cleveland Electric Illuminating Company	20		None	1,051.20	1,205.00	52.00
Commonwealth Edison Company of New York	30		25.00	1,075.51	1,327.50	54.00
General Public Utilities Corporation	43		5.00	1,104.80	1,397.50	66.00
National City Bank of New York	25		None	1,343.75	1,331.25	52.50
Norfolk and Western Railroad Company	25		25.00	1,207.32	1,000.00	87.50
Pacific Gas and Electric Company	30		25.00	1,145.53	1,312.50	64.50
Public Service Electric and Gas Company	50		None	1,387.56	1,362.50	-o-
				$ 9,878.61	$10,605.00	$ 466.50
				$59,386.41	$62,115.20	$1,973.54

Exhibit F—Marketable Secudities as of June 30, 1954 (Cont.)

Add:		
Cash on deposit at June 30, 1953	$ 379.25	
Proceeds from sale of securities	3,180.71	
Dividends and interest received on securities sold or redeemed	153.82	
Transfer from current funds	14,188.70	17,902.48
		$19,876.02
Deduct:		
Purchase of securities	$17,133.87	
Interest purchased	129.11	
Bank service charges	6.42	17,269.40
		$ 2,606.62
Cash on deposit at June 30, 1954—Cleveland Trust Company		$ 438.60
Cash on deposit at June 30, 1954—Ball, Burge & Kraus—brokers		2,168.02
	TOTAL	$ 2,606.62

Certificate of Audit

We have examined the balance sheet of American Society for Quality Control, Incorporated as of June 30, 1954, and the statement of cash receipts and disbursements for the year then ended, and, without making a detailed audit of the transactions, have examined or tested accounting records maintained by the Treasurer of the Society, and other supporting evidence as hereinafter outlined.

Petty cash funds were reported to us by the custodians of the funds. Cash on hand for deposit and cash on deposit at June 30, 1954, was reconciled with amounts confirmed to us by the depositaries. We traced the recorded cash receipts for a period of four months, selected by us, to deposits shown by bank statements on file, and examined canceled bank checks, invoices, and other data supporting the recorded disbursements for the same period. We satisfactorily accounted for the recorded cash received for membership dues for the year ended June 30, 1954, by inspection of the underlying records. We also reconciled recorded amounts for sales of advertising and reprints for the year ended June 30, 1954, with amounts reported to us by the Managing Editor of the Society publication.

Marketable securities, held in custody of the Deputy Treasurer, were inspected by us, and we reconciled the reported income therefrom with the cash on deposit which was reported to us by Cleveland Trust Company.

Accounts receivable at June 30, 1954, are included as shown by unpaid invoices on file as of that date, and deferred income is based upon the underlying records.

In our opinion, based upon our examination as outlined above, the accompanying balance sheet and statement of cash receipts and disbursements present fairly the financial position of American Society for Quality Control, Incorporated at June 30, 1954, and the recorded cash transactions of the Society for the year then ended.

ERNST & ERNST
Certified Public Accountants

Cincinnati, Ohio
July 23, 1954

Certificate of Auditing Committee

Ernst & Ernst, Certified Public Accountants, were retained to audit the books of the American Society for Quality Control, Inc. Relying on this audit and the certificate of Ernst & Ernst, we are of the opinion that the accompanying Balance Sheet and Statement of Receipts and Disbursements fairly present the financial position of the Society as of June 30, 1954, and its recorded cash transactions for the fiscal year ending that date.

Auditing Committee,

HOWARD R. BOLTON
CLARENCE R. BURDICK
G. RUPERT GAUSE
JOSEPH R. SADOWSKI
HOWARD L. JONES, *Chairman*

Appendix C—Report of the Tellers' Committee

Of the 8084 ballots and proxies sent out to the membership, 3575 ballots and 3230 proxies were sent in before the Annual Meeting on June 9, 1954 in St. Louis. Three ballots and proxies were received at the meeting.

Two of the 3578 ballots were disqualified by the Tellers' Committee. The tally of the remaining ballots was as follows:

	No. of Votes
For President	
Raymond S. Saddoris	3 482
Others	41
Not Voted	53
For Vice Presidents	
Arthur Bender, Jr.	3 330
Paul A. Robert	3 269
Julian H. Toulouse	3 274
Others	66
Not Voted	789
For Executive Secretary	
Dorian Shainin	3 485
Others	18
Not Voted	73
For Treasurer	
Leon Bass	3 502
Others	6
Not Voted	68

Amendments to the Constitution

Providing against misinterpretation of Constitutional purposes of the Society

For	3424
Against	17
Not Voted	135

Reducing dues of Fellows of the Society

For	3 152
Against	269
Not Voted	155

The slate of officers selected by the Nominating Committee was elected according to Section 59b of the Constitution. No other person, whose name was written in, received more than three votes for any one office.

The adoption of an amendment "requires a total qualified and valid vote (for and against it) of at least one-fourth of the corporate members of the Society in good standing, and at least three-fourths of that total vote shall have been in favor of such adoption. In addition, such adoption shall require that, with respect to each of at least three-fourths of the Sections, a majority of the ballots cast by affiliated corporate members shall have been in favor of the amendment" (Section 68). The attached table shows that the conditions of Section 68b were met by the vote on both amendments.

However, Section 61d of the Constitution states that a quorum "for the transaction of business affecting its (the Society's) organization or policies, present in person or by proxy, shall consist of one-half of the corporate members of the Society in good standing." The first amendment, which changes the purpose of the Society, also involves a change in the Articles of Incorporation, and thus the vote of 50% of the membership was needed.

For this purpose, proxies were sent out with the ballots so that at least 50% of the membership might vote for the change in the Articles of Incorporation at the Annual Meeting. The tally of the proxies is as follows:

	No. of Proxies
For	2 535
Undesignated (may be voted For)	676
Against	11
Invalid	11

The total number of valid proxies was 3222, which represents only 39.9% of the membership at the time the ballots were sent out. Thus there was not a quorum for voting the change in the Articles of Incorporation.

Since Section 69b of the Constitution states: "No duly adopted amendment to this Constitution, which is in conflict with the Articles of Incorporation of this Society, shall become effective until said Articles of Incorporation have been similarly amended to eliminate such conflict, . . ." the first amendment cannot become effective at this time.

The second amendment, which provides for equalizing the dues of the Senior and Fellow grades, was adopted and will become effective on July 1, 1954.

Members of Tellers' Committee

Miss M. S. Harold, Bell Telephone Laboratories

Mr. C. J. Keyser, Bell Telephone Laboratories

Mr. P. B. Proctor, Johns-Manville Corp.

Mrs. Allegra Rodgers, E. R. Squibb and Sons

Miss M. N. Torrey, Bell Telephone Laboratories

For the Committee

Mary N. Torrey, Chairman
Tellers' Committee

Tally of Votes on Constitutional Amendments

	Providing Against Misinterpretation			*Reducing Dues of Fellows*		
	For	*Against*	*% For*	*For*	*Against*	*% For*
New England						
Albany	56	0	100	44	2	96
Boston	70	0	100	61	10	86
Buzzards Bay	16	0	100	15	1	94
Burlington	11	0	100	11	0	100
Hartford	64	2	97	53	11	83
New Hampshire	11	0	100	11	0	100
New Haven	31	0	100	26	5	84
Rhode Island	29	1	97	27	2	93
So. Connecticut	53	0	100	48	7	87
W. Massachusetts	48	0	100	46	3	94
Worcester	38	0	100	35	2	95
Middle Atlantic						
Allentown-Bethlehem	22	0	100	22	0	100
Baltimore	47	0	100	42	5	89
Carolinas	27	0	100	26	1	96
Delaware	32	0	100	30	2	94
Harrisburg	41	0	100	38	1	97
Lansdale	20	0	100	19	0	100
Metropolitan	315	0	100	312	3	99
Philadelphia	117	1	99	103	14	88
Richmond	22	0	100	20	1	95
Trenton	14	0	100	14	0	100
Washington	40	0	100	31	9	78
Northern						
Buffalo	34	0	100	31	3	91
Mid-Hudson	36	1	97	35	3	92
Montreal	30	0	100	26	4	87
Rochester	76	0	100	75	1	99
So. Tier	39	0	100	36	2	95
Syracuse	62	0	100	56	4	93
Toronto	48	0	100	46	2	96
Utica	16	0	100	15	1	94
W. Ontario	30	0	100	28	2	93
Scranton-Wilkes Barre	18	0	100	17	1	94
Central						
Birmingham	16	0	100	16	0	100
Cincinnati	50	0	100	49	1	98
Cleveland	135	0	100	115	20	85
Columbus	37	0	100	33	4	89
Dayton	37	0	100	32	5	86
Erie	19	0	100	17	2	89
Georgia	28	0	100	26	2	93
Grand Rapids	26	0	100	26	0	100
Gr. Muskegon	7	0	100	6	1	86
Huntsville	5	0	100	4	1	80
Louisville	28	0	100	26	2	93
Michigan	159	1	99	136	23	86
Parkersburg	11	0	100	10	1	91
Pittsburgh	55	0	100	49	6	89
Tennessee	35	0	100	33	2	94
Toledo	36	1	97	34	3	92
Youngstown	17	0	100	16	1	94
Midwest						
Baton Rouge-New Orleans	11	0	100	10	1	91
Central Illinois	23	0	100	21	1	95
Chicago	250	4	98	241	14	94
Dallas-Ft. Worth	30	1	97	29	2	94
Denver	21	0	100	19	3	86
Evansville-Owensboro	12	0	100	12	0	100
Indianapolis	91	2	98	86	5	94
Iowa	100	0	100	98	1	99
Kansas City	13	0	100	11	2	85
Lincoln	18	0	100	15	3	83
Milwaukee	98	0	100	90	10	90
Minnesota	47	1	98	43	5	90
Muncie	28	0	100	26	2	93
N. E. Indiana	25	0	100	21	5	81
Racine	17	0	100	17	0	100
Rock River Valley	26	0	100	24	1	96
St. Louis	57	0	100	52	4	93
South Texas	36	0	100	34	1	97
Wichita	23	0	100	20	3	87
Western						
Albuquerque	12	0	100	12	0	100
Japan	0	0	..	0	0	..
Los Angeles	86	1	99	72	15	83
Mexico City	5	0	100	5	0	100
Salt Lake City	10	0	100	10	0	100
San Diego	35	0	100	31	4	89
San Francisco	43	0	100	38	5	88
Seattle	21	0	100	20	1	95
Members at Large	72	1	99	68	5	93
Total	3,424	17	99.5	3,152	269	92.1
% of 8084	42.6%			42.3%		

Appendix D—Report of the Editorial Board

Purpose of the Board

It is the function of the Editorial Board to have operating supervision of *Industrial Quality Control* and all other technical publications of the Society.

Data on Volume X, IQC

Volume X consisted of one issue at 52 pages, four at 68 pages, and one at 142 pages for a total of 466 pages. This is a 14.2% increase over the pages published in Volume IX.

The Index to Volume X was permanently bound as 8 pages of the No. 6 (May) issue. A few copies were also published separately to make it available for those desiring loose copies.

Of the 466 pages in Vol. X, 154.3 were used for paid ads (including classified ads). This is about 33% of the total available space. The corresponding figure for Vol. IX was 40%. Excluding the May issue, paid advertising used 28.6% of the available space in the other five issues of Vol. X. The corresponding figure for Vol. IX was 35%.

About 311 pages of Vol. X were available for non-advertising copy. The approximate distribution of these 311 pages follows.

160.5 pages were used to publish 40 papers averaging about 4 pages per paper and ranging in length from 1.3 to 8.7 pages. This is 22 pages but only one paper more than in Vol. IX.

76.9 pages were required for departmental copy, distributed as follows:

ASQC News:	9 pages total; in all but the March issue
Bibliography:	14.5 pages total; in each of the six issues
Book Reviews:	4 pages total; in July, November, and March only
Local Section News:	25 pages total; in all but July and September issues
Management's Corner:	3.3 pages total; July, November and March only
Practical Aids:	8.8 pages total; in all but July and November issues
Problems Dept.:	3 pages total; in November and March issues only
Scrap Box:	4.3 pages total; in November issue only
What's New?:	5 pages total; in March and May issues only

Departmental activity in Vol. X was 93% greater than in Vol. IX. The major portion of this increase comes from the addition of two new departments, viz., Local Section News and What's New?

56.3 pages were used to handle annual reports, publicity associated with the Seventh and Eighth Annual ASQC Conventions, editorials, publicity items of a miscellaneous nature, and the inclusion of the Vol. X Index as part of the May issue. Convention publicity used only 8% of the non-advertising space in Vol. X; Annual Reports again held a steady 4% of this space as it did in Volume IX and VIII.

17.3 pages were used for miscellaneous items (covers, masthead, table of contents, and filler items). Vol. IX used 18.3 pages in this category.

In summary, Vol. X gained ground in total space available, lost ground in percent of space occupied by paid ads, held about even with Vol. IX in number of papers published, and experienced a very significant expansion in departmental activity.

Qualitatively, the 40 pages appearing in Vol. X may be classified as follows:

General Interest	15
Sampling	5
Management	4
Technical and Semi-Technical	16

News Supplement

Publication of the News Supplement in months alternate to that of IQC was continued under the editorial management of George Foster. In addition, the services rendered by this supplementary publication were expanded by opening a new department in IQC, beginning with the November issue, under the title "Local Section News." In effect, the Society now has a 12 issue News Supplement which thus makes possible better service in the matter of section news items.

Reprints for Contributors

During Vol. X 28 orders totaling 6650 reprints were handled for contributors. A little better than 47% of the total cost of these reprints was borne by ASQC under its shared-cost policy for contributor reprints. This is 2600 copies less but four orders more than were handled during Vol. IX.

Supplementary ASQC Publications

During Vol. X, the only supplementary publication issued by ASQC was the Aircraft Supplement No. 1 published as an activity of the Aircraft Technical Committee in connection with its two-day conference in Dayton, Ohio, on November 16-17. Copies of this supplement were made available to members of ASQC not attending the conference on their written request to the New York office of the Society.

Reader Survey

During Vol. X the Society, working through the New York and Editorial Chairman's offices, conducted a questionnaire survey of Society membership to get an expression of opinion regarding such questions as size and frequency of publication for IQC, character of editorial content of IQC, extent to which readers use and circulate their copies, interest in and use of the News Supplement, and type of industry and position and responsibilities within the company of the respondent.

The questionnaire went to a representative sample of 811 ASQC members, of whom 326 had replied by the time results were finally analyzed (April 5).

The analysis showed a 3:2 preference for 12 issues vs. 6 issues per year for IQC. In view of the increased costs required to translate this preference into action, the Executive Committee, at its meeting in St. Louis, June 10, postponed decision on this question until further information on financing the expansion could be made available.

As to the character of the editorial content of IQC and the extent to which the journal is read, no startling conclusions appeared. Our readers are apparently making good use of the journal. They appear to prefer relatively short papers of general interest emphasizing practical applications rather than long articles or too many articles emphasizing technical or statistical details. Some 77% reported that they circulate the magazine within the company, the modal number of additional readers being at 3-4.

The News Supplement received a 2:1 endorsement as between those who read it regularly and those who read it occasionally; only 6% reported that they never read it. The majority of respondents expressed a preference for the policy now in force: separate publication in alternate months and as a regular part of IQC.

Responses on type of industry showed electronics, metal fabrication, aircraft, and automotive, in that order, as the

dominant industrial segments reported, although the total classification of all responses provides a nearly panoramic picture of the American industrial scene.

On position within the company, inspection, quality control engineer, quality control supervisor, and manager of quality control, in that order, are the four leading designations reported, although here too the sample showed ASQC members in virtually every area and level of company organization.

Editorial Board

The following men have accepted appointment to the Editorial Board for a five-year term beginning July 1, 1954: Charles Bicking, Allen T. Craig, and B. H. Lloyd.

The three men retiring from the board as of June 30, 1954, were Harold F. Dodge, Lloyd A. Knowler, and Edwin G. Olds.

The Editorial Board for the fiscal year 1953-1954 was honored by having two of its members chosen to receive Society awards. Harry G. Romig received the 1953 Shewhart Medal, and Edwin G. Olds received the 1953 Brumbaugh Award.

Manuscripts

As of June 30 the manuscript status was as follows:

Manuscripts accepted and awaiting publication..... 38

Manuscripts in process, i.e. under review by a referee or in the hands of the contributor for revision... 44

1954 ASQC Convention Papers under review for possible publication in IQC..... 60

Accepted manuscripts assigned publication credit under the Section Management Award rules..... 4

Of the 40 papers published in Vol. X, 13 were papers coming to IQC by way of an annual ASQC convention program; the other 27 were submitted directly to the journal.

Activation of "What's New?" Department

Beginning with the March issue, a new department was opened under the title "What's New?" Roy A. Wylie of the Micro-Switch Division, Minneapolis-Honeywell Co., has accepted appointment as editor of this department. Its function will be to screen publicity releases on new equipment, facilities, or special literature and report objectively to our readers those items that appear to deserve attention in the SQC field.

For the Editorial Board,

MASON E. WESCOTT
Chairman

American Society News

OPERATING COMMITTEE MEETING

The Operating Committee of the Society, consisting of the elected officers and the chairman of the Editorial Board, consider in some detail the many problems and questions that seem to arise all the time in the workings of a Society both as large as ours is, and also still growing at a rapid rate. Important matters, upon which action should be taken, are then thoroughly gone over and sifted to the point where recommendations can be made to the appropriate Society group for possible approval. That group is usually the Society's Executive Committee.

Such an Operating Committee meeting was held in Milwaukee all day Friday, July 30 and a good part of Saturday, July 31. While much of the detail of the meeting should be considered by the Executive Committee before being reported to the membership (their next meeting will be in October), certain actions of the Operating Committee indicate pending actions which should be of general interest.

The membership of the Nominating Committee for 1954-55 was agreed upon, and will be submitted to the Executive Committee for approval. An interesting departure from precedent concerns the chairman of this group. He has always been the junior past president of the Society. The Operating Committee has accepted Al Davis' recommendation that this precendent be broken.

On this subject, as a point of information, it might be well to mention in this column that every year from about one to a dozen members raise the question with the Executive Secretary, or some other officer, about multiple nomination for the same office. A decision is made each year as to whether to have a contest for each office, or whether first to agree on an acceptable man for the office and then whether the getting of an agreement from his employer to let him devote the time, etc., to the job is predicated on the absence of a likely contest. That decision is made by the Nominating Committee alone. It is interesting that each committee has so far not made multiple nominations, even though the members of the committee have not been the same ones over the years.

The operating budget for the year was approved. There is a growing trend in recent years to allocate more funds to the various Society committees to permit greater services to the membership.

Active steps are now being taken to secure larger quarters for the Society's New York office, which will permit another increase in the staff of salaried personnel. The continued growth of the Society has resulted in some deterioration of service to the members with the present staff of this office. This move is clearly now in order.

Each section of the Society will be advised of the appointment of a local Examining Committee by the Society's Examining Committee. Its job will be to act on new member applications and on transfer applications to Senior Member grade, as well as to nominate and/or to provide information to the Society committee on candidates for Fellow. Rules for the local committees and new forms of application blank will be forthcoming.

At the Board of Directors' Meeting at the St. Louis Convention in June, the Society's grouping of Sections for the purpose of electing Directors was changed from six Districts (formerly called Regions) to 16 Districts. Regions, as such, will

AMERICAN SOCIETY FOR QUALITY CONTROL INCORPORATED

ORGANIZATION CHART–1954-1955

WORKING RELATIONSHIPS

While the organization structure on this chart defines lines of responsibility, authority and accountability, it does not indicate or limit work channels and the flow of information. Organization policy expects and permits the exercise of common sense and good judgment at all organization levels in determining the best channels for expeditious handling of society work. Contacts and flow of information should be carried out in the simplest and most direct way practicable. However, it is the duty of each member to keep his superior informed regarding any matter

1. For which his superior is held properly accountable.
2. Which requires the advice of his superior or coordination by his superior with other parts of the society.
3. Which involves recommendations for changes in or variance from established policy.

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The Executive Secretary, Dorian Shainin, is the secretary of the Board of Directors and of the Executive Committee.

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Raymond S. Saddoris

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Arthur Bender, Jr., Liaison Officer

A district representative serves two functions. He conducts the election of directors in his district, reporting to the executive secretary. As the liaison among sections in his district and between them and the society, he reports to the vice president responsible for Membership Relations.

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  Printing: News Supplement, Standard Reports, Div. & Tech. Comm. Pub., General Publications, Yearbook

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- Steering Committees on Applied Methodology — C. C. CRAIG
- Committee on Other Technical Societies — NORMAN KRAVITZ
- Operations Research Committee — P. S. OLMSTEAD
- Standards Committee — H. L. DODGE
- Brewing Industry Steering Committee — D. F. SAGER
- Dues Structure Committee — D. G. BROWNE

Executive Secretary
DORIAN SHAININ
- Headquarters Office—New York
  J. S. HERZ, Manager
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- Constitution & By-Laws Committee — G. D. EDWARDS
- Examining Committee — P. S. OLMSTEAD
- Section Affairs Committee — C. J. HUDSON
- Yearbook Committee — C. E. FISHER

Treasurer
LEON BASS
- Financial Records & Reports Collections
- Financial Advisory Committee — W. R. WEAVER

The treasurer is the liaison officer between the financial advisory committee and the executive committee, which is the finance committee of the society.

still exist at the option of the interested sections to conduct conferences and to cooperate in other ways to promote the objectives of the society. At this Operating Committee meeting detailed plans were laid to convert the present six District Representatives to 16 District Representative. Each section will participate in the conversion process in accordance with the arrangements it makes with the present District Representative (one of the six people).

The Society will have in the hands of each section's program chairman several copies of the Author's Manual for the Preparation of Articles for *Industrial Quality Control*. Prospective authors please note, and inquire of your section program chairman.

Approved was the publication of an index, catalogued by subject, of all the papers presented in the first ten volumes of *Industrial Quality Control*.

There are indications from around the country that work for the Presidential Award for Section Management will be still more competitive than last year. Sections are currently being advised of appropriate changes in the rules which were worked out by the committee for the Award at St. Louis.

MEMBERSHIP CORNER

The National Membership Committee has asked the various sections who placed near the top of the Presidential Award competition to write a short article on how their Section organized to achieve this success and improve their membership position. The first article was submitted by Robert Anderson, 1954-55 Chairman of the Columbus Section, which was in second place.

Section officers, under the chairmanship of Gordon A. Olson, formed the nucleus of a Committee involving the program chairman, publicity chairman, and membership chairman, for the express purpose of coordinating activity that would improve Section management.

Special meetings were held to bring about improved coordination of efforts within the Section to attain a top competitive position within the Society.

Particular emphasis was placed upon the following Section activities by the Committee:

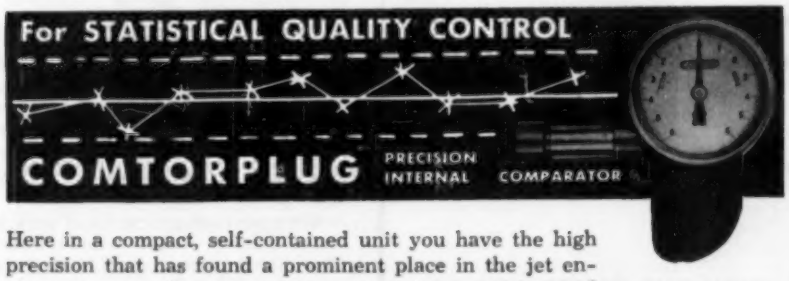
1. PROGRAM ACTIVITIES

Early development of a complete program series was emphasized; culminating in the printing of a small attractive booklet with announcements and photographs of the forthcoming meetings for the entire year. The announcements for each month carried a brief resume of speaker's background, plus brief descriptions of subject matter to be presented.

An annual feature of the Columbus Section is a Management Dinner Meeting, for which a well-known authority is obtained to address management guests along with members on the quality control job with special emphasis on management points of interest.

On December 16, 1953, a special social evening program was planned for members and guests. This event proved most successful.

Four meetings were dinner meetings. At the other meetings refreshments were provided, generally coffee and doughnuts, at the conclusion of the principal address, which provided members with an opportunity for informal discussion following the main meeting.



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2. EDUCATIONAL ACTIVITIES

Two basic training programs, consisting of 14 hours each (seven 2-hour sessions), were presented during the fall months—one in Columbus on Monday nights and one on Friday nights in Newark, Ohio at the request of the members from the Newark area.

The training course was available to members at $10.00—or to non-members at a $10.00 increase in fees to cover membership in the Society.

Forty-five new members were acquired through presentation of these two training courses.

3. PUBLICITY ACTIVITIES

All monthly meetings were announced in at least three local newspapers, the regular Society publications, and in the Columbus Technical Council publication which is distributed to all society members whose Chapters are affiliated with the Council.

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ASQC Has a New Home!

Please note the following important change of address. On August 23 the Society Headquarters Office moved to larger offices at:

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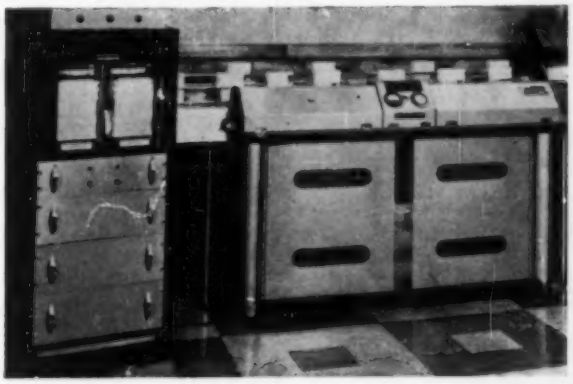

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Individual Back Copies	$1.50
Library Subscriptions (Current volume)	$6.00
TECHNICAL SUPPLEMENTS SERIES	
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Aircraft Technical Committee, 1953 "Proceedings Aircraft Quality Control Conference" (12 papers) Bound Volume	1.50
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